no. 2
LIBRARY
FISH & WILDLIFE SERVICE
PACIFIC OCEANIC FISHERY
INVESTIGATIONS

CONSEIL PERMANENT INTERNATIONAL
POUR L'EXPLORATION DE LA MER

JOURNAL DU CONSEIL

VOL. IV · NO. 2

PUBLIÉ PAR LE BUREAU DU CONSEIL

RÉDIGÉ PAR

E. S. RUSSELL

EN COMMISSION CHEZ
ANDR. FRED. HØST & FILS
COPENHAGUE

Août 1929

Note.

The Journal of the Council will in future appear *three times a year*, and three numbers will form a volume. It will include, in addition to general articles, reviews and bibliography, the special papers hitherto issued in the series of "Publications de Circonstance".

The annual subscription price has been fixed at 12 Kroner (+ Kr. 1.50 for mailing expenses) per volume, which will include, if desired, a reprint of the bibliographical matter, printed on one side of the paper. Single copies will be sold at Kr. 4,50.

A separate edition of Dr. Allen's Selected Bibliography, published in Nos 1 and 2 of the Journal, has been issued, printed on one side of the page only. Subscribers and those on the distribution list will receive copies of this Bibliography *upon application to the Administrative Secretary.*

It may also be purchased for the sum of 1 Krone from the Publisher.

Contributions to the Journal and all correspondence should be addressed: —

The Secretary
Journal du Conseil,
Fisheries Laboratory,
LOWESTOFT, England.

They may be written in English, French, German or Spanish. General and scientific articles must be accompanied by a summary. General articles and reviews will be paid for at the rate of 10 Kroner a page. Authors of general articles and scientific papers will receive 50 copies of their paper gratis. Typescripts and figures should be submitted in a state fully prepared for press, in order that the costs of proof correction may be reduced to a minimum, and no expense be incurred by the Council in re-drawing any figures. *Contributors are requested to follow the instructions printed on p. 3 of the cover.*

Books and papers for review or bibliographical notice should be sent to the Editor.

Orders for copies should be sent to Messrs. Andr. Fred. Høst & Søn, Bredgade, Copenhagen, and business communications, regarding advertisements, etc. to the Administrative Secretary, Strandvej 34, Copenhagen.

CONSEIL PERMANENT INTERNATIONAL
POUR L'EXPLORATION DE LA MER

JOURNAL DU CONSEIL

VOL. IV · NO. 2

PUBLIÉ PAR LE BUREAU DU CONSEIL

RÉDIGÉ PAR

E. S. RUSSELL

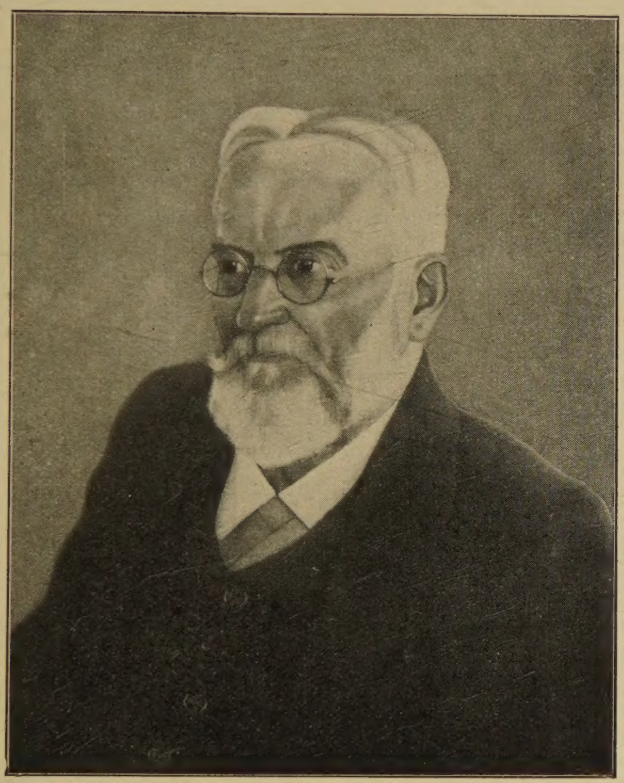
EN COMMISSION CHEZ
ANDR. FRED. HØST & FILS
COPENHAGUE

Août 1929

IMPRIMERIE BIANCO LUNO

Friedrich Heincke.

(1852–1929).



Heincke im Jahre 1927.
Nach einem Gemälde von Hans Ludwig Fischer
im Museum des Instituts für Seefischerei Wesermünde.

Am 5. Juni 1929 verschied auf Helgoland im 78. Lebensjahre der langjährige Direktor der Biologischen Anstalt Professor Dr. Fr. Heincke, zweiter (wissenschaftlicher) Vorsitzender der Deutschen Wissenschaftlichen Kommission für Meeresforschung und Mitglied der Preussischen Kommission zur Erforschung der deutschen Meere in Kiel. Mit ihm verliert die deutsche Fischereiwissenschaft ihren Lehrmeister und die Internationale Meeresfor-

schung einen ihrer Begründer und zuverlässigsten Wegweiser in der Verfolgung ihrer wichtigsten Probleme im Dienste der Seefischerei.

Johann Friedrich Heincke, geb. am 6. Januar 1852, verlebte seine erste Jugend in dem mecklenburgischen Landstädtchen Hagenow, absolvierte 1869 das Gymnasium in Schwerin und studierte bis 1873 in Rostock und Leipzig Naturwissenschaften. Schon als Schüler ein eifriger Beobachter der heimatlichen Tierwelt widmete er sich hauptsächlich der Zoologie. Durch seine bedeutendsten akademischen Lehrer F. E. Schulze und R. Leuckart vor allem für die marine Biologie begeistert und schon durch seine Dissertation auf ichthyologische Untersuchungen hingewiesen, siedelte er nach seiner Promotion im Herbst 1873 nach Kiel über. Hier hatten Möbius, Hensen u. a. den Ruf der Universität als marine Forschungsstätte begründet. Hier war 1870 die Wissenschaftliche Kommission zur Untersuchung der deutschen Meere eingesetzt mit der Aufgabe, im Interesse der Seefischerei die wissenschaftlichen Grundlagen für die Lebensbedingungen, das Vorkommen und die Verbreitung der Fische zu studieren. Hier eröffnete sich dem jungen Heincke das Tätigkeitsfeld, dem er sein langes Forscherleben gewidmet hat in seltener und bis zum Kriege unverminderter Arbeitskraft und in nie erkalteter Begeisterung bis zur letzten Stunde seines Lebens.

Möbius übertrug ihm eine Assistentenstelle am zoologischen Institut, die er bis 1876 verwaltete, gleichzeitig das Universitätsstudium mit dem im Sommer 1875 bestandenen Examen für das höhere Lehrfach beendigend. Infolge des Todes seines Vaters früh darauf angewiesen, selbst für seinen Unterhalt zu sorgen, übernahm er 1876 eine Hilfslehrerstelle in Kiel, vermochte jedoch gleichzeitig seine Tätigkeit an der Universität fortzusetzen, an der er 1877—79 auch als Dozent wirkte. Ausserdem war er seit 1874 Mitarbeiter der Kieler Kommission, die in diesem Jahre beschlossen hatte, ihre biologischen Arbeiten im wesentlichen auf einen Fisch, den Hering, zu konzentrieren. Dabei übertrug sie Heincke die Untersuchung der seit Nilsson viel umstrittenen und für die Verfolgung der Wanderungen und die Beurteilung der Fischereien des Herings sehr bedeutungsvollen Frage, ob es constante, sicher unterscheidbare Rassen des Herings gäbe. Ihr Vorhandensein konnte er bejahen und als erster beweisen auf

Grund der von ihm verwendeten exakten Forschungsweise, die er unbeirrbar verfolgte bis zum Erfolge, trotzdem seine Gründlichkeit anfangs von einem seiner Auftraggeber als zu weit getrieben und unfruchtbar getadelt worden war, wie HEINCKE oft selbst erzählt hat. Mit seinen »Varietäten des Herings« lieferte HEINCKE den bedeutendsten Beitrag zu den im Jahre 1878 veröffentlichten Ergebnissen der Kieler Heringsuntersuchungen und zugleich mit dem 1881 erschienenen zweiten Teil dieser Arbeit eines jener Fundamente der modernen Meeresforschung, die wir der Kieler Kommission verdanken.

Infolge seiner Verheiratung genötigt, zur Versorgung seiner Angehörigen eine fest besoldete Stelle zu suchen, musste der junge Gelehrte die akademische Tätigkeit aufgeben und wurde 1879 Oberlehrer in Oldenburg. Die Begeisterung am Forschen liess ihn jedoch neben seinem Amt noch weitere bedeutende, z.T. noch heute viel benutzte Arbeiten über Fische und andere Meerestiere teils als Frucht seiner Kieler Studien vollenden, teils in ständiger Verbindung mit der Kieler Kommission neu beginnen. Auf Einladung von HENSEN nahm er 1885 an der denkwürdigen »Holsatia«-Fahrt teil, die als Vorläufer der bekannten Plankton-Expedition die überraschende Entdeckung von der Armut des offenen Ozeans an Urnahrung für die Fische im Vergleich zur Nord- und Ostsee gemacht hat.

In dieselbe Zeit fällt die Gründung der Sektion für Küsten- und Hochseefischerei, des später selbständigen Deutschen Seefischerei-Vereins, und HEINCKE's Verbindung mit dem Vorsitzenden dieses Vereins Dr. HERWIG, dem erfolgreichsten Führer der deutschen Fischerei. Dieser Förderer der Fischereiwissenschaft und später erste Präsident der Internationalen Meeresforschung erkannte in HEINCKE alsbald nicht nur den tiefgründigen und geistvollen Forscher, sondern auch den geeigneten Vermittler zwischen Wissenschaft und Fischerei, den er bei der Durchführung seiner weitreichenden Pläne zum Mitarbeiter und Berater gewinnen musste. Denn HEINCKE besass in hervorragendem Masse die manchem grossen Gelehrten fehlende Gabe, die Ergebnisse der Wissenschaft und ihre Bedeutung für die Praxis in klarer und fesselnder Darstellung weiteren Kreisen zu übermitteln. Ohne die tatkräftige Unterstützung seines einflussreichen Förderers wäre es dem fernab

von den Zentren der Wissenschaft und der Fischerei wirkenden Oberlehrer wohl kaum vergönnt gewesen, seine Fähigkeiten so zu entwickeln und zur Geltung zu bringen, dass ihm zu gegebener Zeit eine führende Stellung in der Meeresforschung übertragen werden konnte.

Wiederholte Beurlaubungen aus seinem Amt und geldliche Unterstützungen ermöglichten HEINCKE die ruhige Fortsetzung seiner Arbeiten und die Erweiterung seines Gesichtskreises. Auf mancherlei Reisen an der Küste lernte er die heimatlichen und ausländischen Fischerei-Verhältnisse kennen, namentlich in Skandinavien und Holland, und seine Studien fanden Ausdruck in zahlreichen Veröffentlichungen. In den Jahren 1888—90 leitete er mehrere Expeditionen des Seefischerei-Vereins auf Fischdampfern zur Erforschung der Wanderungen des Herings und Auffindung seiner Laichplätze. Mit besonderer Aufmerksamkeit verfolgte er schon damals die Entwicklung der in gewaltigem Aufschwung begriffenen Dampf-Trawlfischerei namentlich in Grossbritannien und die dort im Gange befindlichen Untersuchungen über die Schädlichkeit des Scherbrettnetzes und über die Möglichkeit einer übermässigen Beanspruchung des Fischbestandes durch die Dampftrawlerei, die der günstigen Weiterentwickelung der Hochseefischerei bedrohlich erschien. Auch in diesem Fragenkomplex wurde HEINCKE alsbald der erste Sachverständige in Deutschland.

Im Jahre 1891 bot sich HEINCKE endlich die Gelegenheit in eine zur vollen Entfaltung seiner Fähigkeiten geeignete Stellung zu gelangen. Auf HERWIG's Betreiben wurde er Direktor der vom preussischen Staat gegründeten Biologischen Anstalt auf Helgoland. Ausser HARTLAUB als Zoologe und KUCKUCK als Botaniker wurde ihm als Fischereibiologe EHRENBAUM — ebenfalls aus der Kieler Schule hervorgegangen und bisher wissenschaftlicher Referent beim Seefischerei-Verein — beigegeben, der sein bedeutendster Mitarbeiter wurde und ihm während der folgenden 2 Jahrzehnte als Berater und Freund am nächsten stand.

Neben seiner verdienstvollen Tätigkeit in der Leitung und für den Ausbau des neuen Instituts und mannigfachen faunistischen Arbeiten widmete sich HEINCKE weiterhin fischereibiologischen Untersuchungen. In das erste Jahrzehnt der Anstalt fällt die

Beendigung der »Naturgeschichte des Herings« (1898). Dies unzweifelhaft grösste Werk unseres Forschers ist jetzt überall bekannt und liefert die methodischen Grundlagen der Untersuchungen, wo immer in der weiten Welt die Erforschung der wichtigsten der Nutzfische, der Clupeiden, und der Rassen der Fische überhaupt wissenschaftlich betrieben wird. Als zweite Arbeit von fundamentaler Bedeutung darf die mit Ehrenbaum gemeinschaftlich durchgeführte und im Jahre 1900 veröffentlichte Untersuchung über »die Bestimmung der schwimmenden Fischeier und die Methode der Eimessungen« angesehen werden. Erst durch dies Werk ist die erfolgreiche Anwendung der Hensen'schen Methode zur Bestimmung des Fischbestandes vermittelst der Zahl ihrer schwebenden Eier möglich geworden.

Der in den neunziger Jahren auch in Deutschland infolge des schnellen Anwachsens der Fischerflotte brennend gewordenen Frage nach der Möglichkeit einer Überfischung widmete Heincke unablässig die sorgfältigste Aufmerksamkeit. In Wort und Schrift hat er mit der ihm eigenen Klarheit und Überzeugungskraft die Regierung und die Fischereikreise auf die Notwendigkeit grossangelegter wissenschaftlicher Untersuchungen im Dienste der Seefischerei hingewiesen und damit in Deutschland dem Gedanken einer internationalen Meeresforschung den Boden bereitet. Mit Herwig und Hensen und massgeblichen Forschern in anderen Staaten, namentlich Hoek und Herdman, hat er an der Vorbereitung zur Gründung unserer internationalen Organisation mitgewirkt und sich auf deren ersten Versammlungen hervorragend an der Aufstellung der Programme beteiligt.

Das auf den Beginn der Arbeiten im Jahre 1902 folgende Jahrzehnt sah Heincke als Forscher und Organisator auf dem Gipfel seines Schaffens. Er war Mitglied der zur Durchführung der von Deutschland übernommenen Arbeiten eingesetzten Kommission, die ihm bei der Arbeitsteilung die Leitung der Erforschung der Nutzfischbestände übertrug. Als sehr begehrter Expert der Internationalen Meeresforschung und seit 1912 auch als deutscher Delegierter hat er an allen Tagungen des Zentralausschusses bis zum Kriege teilgenommen.

Im Studium der Naturgeschichte der Scholle und der Beanspruchung dieses Fisches durch die Fischerei, den die Internationale

Meeresforschung zunächst als bevorzugten Untersuchungsgegenstand ausgewählt hatte, weil sein Bestand besonders stark bedroht erschien, wurde HEINCKE alsbald der anerkannteste Sachverständige im In- und Ausland, dank der schon von seiner Heringsforschung bekannten wissenschaftlichen Gründlichkeit und methodisch mustergültigen Weise, mit der er seine Untersuchungen ins Werk setzte und durchführte. In zahlreichen Abhandlungen sind die Methoden und Ergebnisse HEINCKE's und seiner Mitarbeiter niedergelegt über die Zusammensetzung des Bestandes nach Geschlecht, Grösse, Gewicht und Altersklassen, über Wachstumsgeschwindigkeit und Wanderungen, über die Bestandsdichte und die Berechnungen des Gesamtbestandes, über die Befischungsstärke und den Einfluss der Fischerei auf die Bestände, über die Fangkraft verschiedener Arten des Trawls u. a. mehr. Als erste Zusammenfassung der Ergebnisse der deutschen Schollen-Untersuchungen erschien 1907 der mit HENKING, der die fischereistatistischen Arbeiten übernommen hatte, gemeinsam veröffentlichte Bericht über Schollen und Schollenfischerei in der südöstlichen Nordsee, der bereits die ersten praktischen Vorschläge zur Schonung durch Einführung von Minimalmassen enthält. Auf Grund dieses allgemeine Anerkennung findenden Werkes wurde HEINCKE zum Generalberichterstatter für diesen wichtigsten Untersuchungsgegenstand der Internationalen Meeresforschung ernannt mit der Aufgabe, die von sämtlichen Ländern erzielten Ergebnisse über die Scholle und ihre Befischung zusammenzufassen. Der i. J. 1913 veröffentlichte Generalbericht darf als drittes grosses Standardwerk HEINCKE's angesehen werden. Weit hinausgehend über die Bedeutung für das Verständnis der Schollen-Biologie und Schollen-Fischerei liefert diese Arbeit ein Musterbeispiel, wie man durch umfassende Erforschung aller biologischen und fischereilichen Verhältnisse einer Nutzfischart zu wissenschaftlich begründeten Vorstellungen über ihre Mengen- und Produktionsverhältnisse, über die Grenzen ihrer Ausnutzungsmöglichkeit und daraus zu berechtigten Vorschlägen für die im Interesse eines dauernd ergiebig bleibenden Fischereibetriebes notwendigen Schonmassnahmen gelangen kann.

Auf Grund des Generalberichtes wurden vom Zentralausschuss in London 1913 die ersten Vorschläge für ein internationales

Mindestmass für die Nordsee-Scholle vereinbart und den beteiligten Regierungen vorgelegt. Die Verwirklichung dieses ersten praktischen Schrittes zu einer internationalen Regelung des Fischereibetriebes vereitelte der Ausbruck des Krieges.

Heincke musste die Seefestung Helgoland verlassen und siedelte nach Oldenburg über, wo er seine Arbeiten nur in beschränktem Umfange fortsetzen konnte. Sie betrafen vornehmlich die Unterschiede in den Alters- und Wachstumsverhältnissen der Schollen verschiedener Meere. Die Untersuchung namentlich des von der »Poseidon«-Expedition in das Barentsmeer (1913) gesammelten Materials bestätigte seine Erwartungen von den völlig abweichenden Verhältnissen in einem durch die Fischerei noch wenig veränderten Bestand.

Die während des Krieges in Helgoland angestellten Beobachtungen zeigten bald eine Anreicherung und weitgehende Veränderungen in der Zusammensetzung des Fischbestandes infolge des Aufhörens der grossen Trawlfischerei. Eine eingehende Untersuchung des durch diese unfreiwillige Schonung entstandenen Zustandes vor dem Einsetzen einer erneuten hemmungslosen Fischerei und seine weitere Beobachtung unter der Einwirkung derselben musste für die Frage der Überfischung und der Schonmassnahmen von grösster Bedeutung sein. Heincke verfasste eine Denkschrift über die Notwendigkeit der Wiederaufnahme der Bestandsuntersuchungen sofort nach dem Kriege, die durch seine skandinavischen Freunde auch dem Internationalen Zentralausschuss unterbreitet wurde, aus dem Deutschland nach Kriegsausbruch ausgeschieden war. Ungeachtet der damals erklärlicherweise ungeheuren Schwierigkeiten setzte er den Beginn dieser Arbeiten mit dem »Poseidon« im Sommer 1919 durch und leitete nach Helgoland zurückgekehrt die eingehende Untersuchung der veränderten Verhältnisse des Fischbestandes, der er sich nach seiner Pensionierung i. J. 1921 mit den ihm von der inzwischen reorganisierten Deutschen Wissenschaftlichen Kommission beigegebenen Assistenten ganz widmen konnte. In mehreren Abhandlungen sind die Ergebnisse dargelegt, die durch den Vergleich des gering befischten Bestandes in der Kriegszeit mit dem bald wieder in alter Stärke befischten Bestand einen überzeugenden Beweis von der starken Einwirkung der Fischerei auf die Grösse und Zusam-

mensetzung der Bestände erbrachten. Wiederholt hat der greise Forscher auf Helgoland seine warnende Stimme erhoben gegen eine masslose Befischung und dargelegt, wie nur bei ihrer Einschränkung durch massvolle Schonung namentlich auf den Jungfischgründen eine dauernde Ertragsfähigkeit der Schollengründe gewährleistet sei. Auch an der Prüfung des zuerst von der englischen Forschung empfohlenen und dann auch von ihm befürworteten Schongebietsplanes konnte er sich noch beteiligen und Pläne für weitere Untersuchungen entwerfen, die notwendig wurden, teils infolge der Feststellung der Verminderung der Wachstumsgeschwindigkeit des aufgehäuften Bestandes, teils durch die von ihm schon 1913 geprüfte Frage nach dem Vorhandensein und der Bedeutung von natürlichen Fluktuationen in der Stärke der Jahrgänge. Auf eine aktive Mitarbeit musste Heincke zwar wegen seiner geschwächten Gesundheit mehr und mehr verzichten. Seine wichtigste Aufgabe sah er jetzt darin, der jüngsten Gelehrten-Generation den Schatz seiner Erfahrungen zu übermitteln und sie in seine Methoden einzuführen. Und in der Tat ist dies wohl das grösste Verdienst der letzten Arbeitsjahre unseres Lehrmeisters um die deutsche Fischereibiologie, der infolge des Krieges der wissenschaftliche Nachwuchs verloren gegangen war. Von den heute in der Arbeit stehenden Forschern ist in Deutschland wohl keiner, der sich nicht des Verstorbenen Schüler nennen könnte, und viele sind in der Internationalen Meeresforschung, die auf seinen Ideen und Methoden weiterbauen.

Nach langem gesegnetem Leben ist er nun dahin gegangen. Sein Name aber wird fortleben, solange wir Herings- und Rassenforschung treiben, solange die schwierige Frage einer Überfischung des Meeres die Menschen beschäftigen wird, solange es eine praktisch wissenschaftliche Meeresforschung giebt. Und diese wird nicht aufhören, solange das Meer seine Bedeutung behält als Nahrungsquelle der Völker.

Wir alle betrauern den Heimgang eines grossen Forschers. Mehr aber verlieren diejenigen, denen es noch vergönnt war, diesen aufrechten, doch trotz aller Ehrungen bescheidenen und anspruchslosen Mann mit dem heiteren und reinen Gemüt Freund zu nennen.

W. M.

The Regulation of the Halibut Fisheries of the Pacific Coast of North America.[1])

By

William F. Thompson.

International Fisheries Commission, Seattle, Washington.

The treaty placing the Pacific halibut fisheries under regulation did not originate in a careful and deliberate attempt at scientific control. It developed rather from the consciousness of the fishermen of the two nations concerned that something should be done. As early as 1916, a bill was introduced into the Congress of the United States providing for the closure of certain areas and the imposition of a closed season during the winter, and it was proposed that this bill would become effective upon the passage of similar legislation by Canada. The halibut fisheries were to be controlled by concurrent legislation. The measure had its origin in the belief of the fishermen that the banks were becoming depleted. This belief was strengthened by the scientific work done under the direction of the British Columbia Fisheries Department, wherein the rapid decline in the abundance of halibut on the banks was indicated and the general features of the life history of the species were described. The legislation came to naught — the idea, however, did not die.

The halibut fisheries continued their decline and the fishermen, faced with voyages to distant seas during the severe part of the winter, realized not merely the value of regulation from the standpoint of conservation but also the value of regulation from the standpoint of economics and their own safety. They did not wish to be forced by mutual competition to operate during a relatively expensive and non-productive part of the year when danger and discomfort were at a maximum. The development of cold storages made this unnecessary, and gave the added

[1]) This is not an official statement of the views of the Commission for regulation of the halibut fisheries but is a discussion of the ideals underlying the work of its scientific staff.

incentive of a profitable winter market for frozen summer halibut, providing fresh halibut were out of the market. The result was the treaty of October, 1924.

This treaty was notable from several aspects. It was the first which Canada negotiated in her own right, and marked a change in her status within the British Empire. It was the first effective treaty for the control of a deep sea fishery. However, the situation was a simple one compared to that which exists elsewhere, for two nations similar in population, ideals and language were concerned. The interests involved in the fishery were to all intents and purposes identical on both sides of the international boundary line. In fact, it cannot be doubted that the most unusual and favorable conditions assisted the conclusion of this treaty.

But, despite the favoring circumstances, those features of the treaty which may ultimately make for scientific control, came into being indirectly, through regulation financially agreeable to the trade, rather than through a set effort at a scientific measure calling for sacrifice. In this fact there may be a suggestion for those men convinced of the necessity for international control in the North Sea and elsewhere.

The treaty provided very briefly for a closed season of three months from November 16th to February 15th. This closed season was as has been said, largely an economic measure and one inspired by the fishermen and dealers themselves from their own ideas as to what conservation should consist of. The treaty did, however, provide for a Commission to exist as long as the convention was in force, with the duty of scientific investigation, upon which it should report with recommendations as to desirable regulations. This in itself was a remarkable feature of the treaty, since the ordinary investigative commission is one with a definite term of life and with a rather prescribed field of inquiry. It is hoped that it will prove to have been in fact the basis for a really scientific future control of the halibut fishery.

The Commission consists of four members, two from each country. They are at present the chiefs of the fisheries staffs, respectively Canadian Deputy Minister of Fisheries, Mr. Found; United States Commissioner of Fisheries, Mr. O'Malley; and two men from the Pacific Coast, namely Mr. Miller Freeman, publisher of the Pacific Fisherman, and the Chairman, John Pease Babcock, Assistant Commissioner of Fisheries for the Province of British Columbia.

The Commission met early in 1925, appointed a scientific director, the writer, and gave him powers for the inauguration of a program of scientific work and the employment of a suitable staff. The Commission previously to the appointment of this Director, had from him an outline

of a proposed program, and in assenting to this program, the Commission emphasized its attitude that the investigation should be as practical as possible and should lead rapidly to definite recommendations. The staff was collected and had begun its work in June of 1925. It necessarily consisted of young, energetic men, since the work at sea is of the hardest and most disagreeable character. The expenses have been paid in equal shares by the two governments.

The program of scientific work which was undertaken involved first of all the study of the condition of the fishery, a task fairly definite in its nature, insofar as it was statistical and descriptive. But the program also included the collection of facts which would indicate the regulations necessary to improve those conditions. This was far more difficult, because the principles governing the reaction of a species to the strain of fishing are unknown. And although such was not clearly evident in the beginning of the investigation, it has become clearer as time has gone on that the function of the scientific staff cannot be to lay down definite rules leading to known results but to act rather as an instrument of the executive, as an agent of the legislature, its work incidental to what must be termed a great scientific experiment, the rehabilitation of the badly depleted banks of the high seas. Such a staff can provide accurate information and proper means of observation for the future, to guide and support an aggressive executive policy, following a course of action giving promise of favorable results.

The problem of the present condition of the fishery was that faced first by the scientific staff. It was necessarily a statistical problem approached from a biological standpoint. The halibut fishery of the Pacific Coast, as can be seen from casual inspection, is spread over an extremely long, narrow continental shelf, out to depths of 150 fathoms. The fishery is exclusively a hook and line fishery, not involving any other species in mass sufficient as yet to complicate treatment. The men carrying on the fishery are largely Norwegians with an admixture of other northern Europeans and some from the eastern coasts of Canada and the United States. It has been a favorable condition for the gathering of statistics voluntarily contributed by men sympathetic and relatively homogeneous. It has rendered possible the partial repair of a lack of governmental concern in the past as to the course of the fisheries.

The gross statistics of the total yield before 1913 were very defective, with considerable confusion and are hardly worth serious consideration except from the standpoint of the general tendency of the fishery, and this is almost true of the years since 1913. The fishery had its beginning in 1888. It developed rapidly, especially as at that time the supplanting

of sail by steam lent a great impetus to fishing, because of the splendid inside passage ways sheltering from the wind for great distances along the coast. The fishery, beginning with the completion of the first transcontinental railway as a means of access to the eastern markets, expanded with great rapidity, and by 1910 was approximately at its maximum. The vessels landing their fish in Puget Sound were at that time going as far north as southeastern Alaska, and were producing in the neighborhood of 53 millions of pounds yearly. The subsequent history of the fishery has been one of rapid expansion of the grounds. In the years following 1910, the vessels have fished ever northward and westward until in the season of 1928, the first fish to be brought from Bering Sea made their appearance. The extension of the grounds did not increase the total yield — it has remained more or less constant, in the vicinity of 55 millions of pounds annually.

This great expansion was accompanied by a great increase of gear and vessels on the older grounds, the details of which are not to be had because their importance was not realized at the time. Some idea is available, however, as to the total catches from these older grounds and also as to the average catch of a standard unit of gear used by typical vessels. From this it is possible to hazard an estimate as to what the intensity of the fishery may have been. With a total catch in 1910 of 53 millions and an average catch of 260 pounds per unit, the number of sets of a standard unit would be 204,000. With a total of 19 and a half millions in 1926 and an average catch of 50 pounds, the number of sets would be 390,000. It can, indeed, be safely assumed that despite a nearly doubled intensity, the catch has fallen nearly to a third of its original amount. The major part of the seemingly stable total landings therefore comes from new banks, naturally less productive as our records show.

The detailed history of this fall in abundance upon the older banks is of great interest. The writer had, during his work in the year 1916 for the British Columbia government, secured from as many sources as possible the logs kept by the fishing vessel captains, giving particulars of operations and catches, many of them dated as early as 1905. Upon beginning this later investigation in 1925 and during 1926, he was fortunate in obtaining a great mass of these log records giving fishing operations sufficiently far back to connect satisfactorily with the earlier statistics, making a more or less continuous record of the average returns per standardized unit of gear set on the older banks in the period from 1906 to 1926. The results of this record are shown in the accompanying graph, wherein the catch per unit of gear, the "skate" is shown. Since

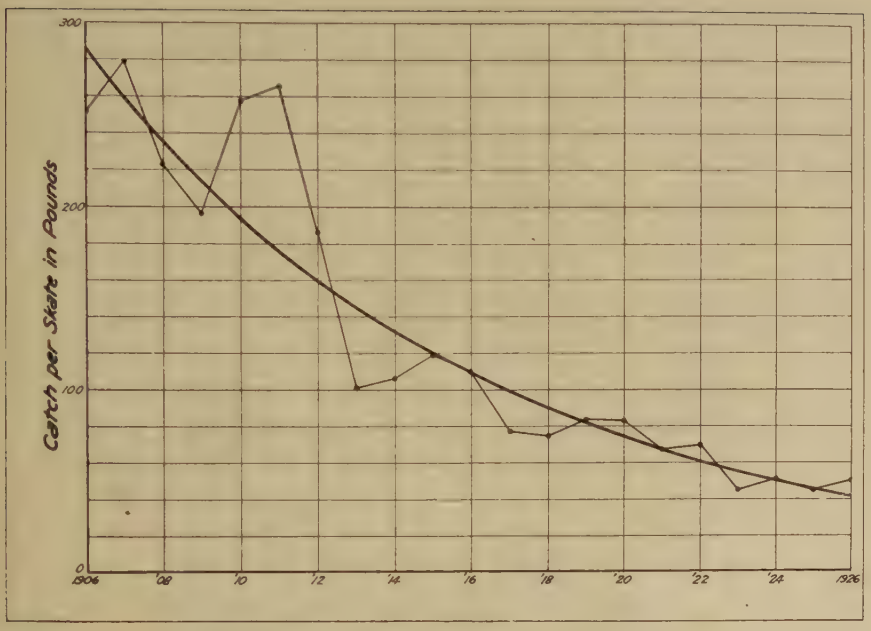


Plate 1. Decline in abundance of fish, as shown by the catch in pounds per set of a standard unit of gear. From 1906 to 1926 on the older banks.

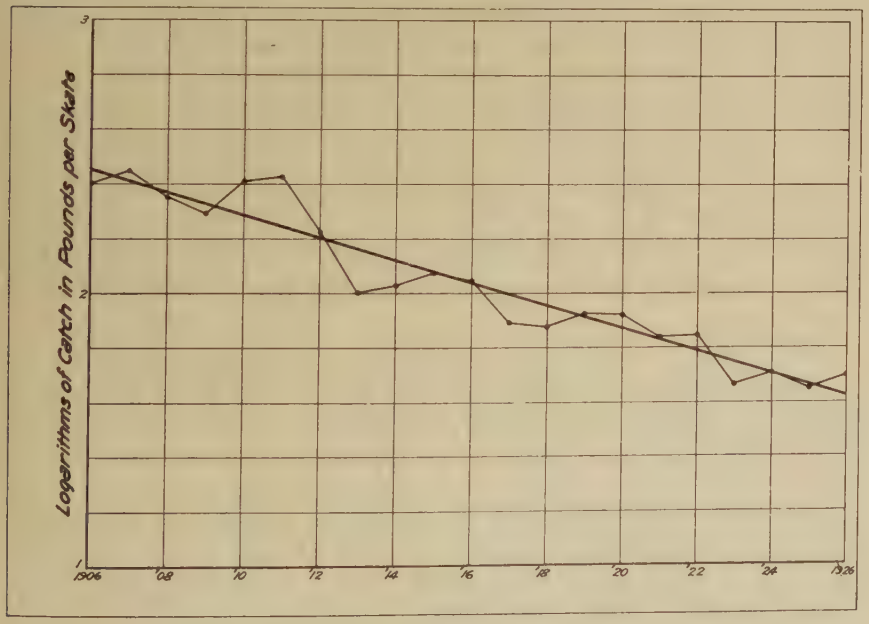


Plate 2. Decline and variability in abundance of fish, as shown by the logarithms of the catch in pounds per set of a standard unit of gear. From 1906 to 1926, on the older banks.

the catch per unit of gear is subject to some correction due to the greater length of the unit used during earlier years, corrected data have been used in the chart. It will be observed that the fall in catch per unit conforms to the shape of an exponential curve, with some irregularities due to the opening of new banks within the area dealt with. The curve for the whole area may be in fact a compound of minor curves with more rapid rates of fall. The curved even line shown is that of a rate of fall of about 10 per cent. annually and the decline (as smoothed) over a period of two decades is from a catch of 300 pounds to under 50 pounds per skate, thus showing a decline of the population to 16 per cent. of its former abundance. For comparison, the decline in total yield is from something in the neighborhood of 53 millions of pounds to $19^1/_2$ millions, or to approximately 37 per cent. of its former magnitude. It would seem that the decline in yield per unit of gear, the skate, has proceeded at a greater rate than the decline in total catch. Despite the regrettable roughness of the figures, there is sufficient reason to conclude that the productivity of the banks is now greater in proportion to the stock existing than it was when they were relatively newly used; but not sufficiently so to mask the decline, or even to modify it to any great degree.

Far more important than this, from the standpoint of the future, is the fact that it is not possible to say whether this increased productivity — or resistance to the strain as it might be stated — is a phenomenon solely of the earlier stages of exploitation or one which has increased in strength as the fishery has declined. However interesting and valuable the record, the lack of this detail hampers seriously the application of its lessons, and such lack should never be forgiven in the future, because as we shall see, it has become a vital matter to know whether the resistance to the strain of the fishery is increasing now or whether it has long ago reached its maximum.

Perhaps one of the most interesting consequences of our investigations has been the study of the present distribution of the fish. Mature fish are not brought in any numbers from the southern banks, although they once were. However, they are yet abundant upon the banks to the westward. It is fair to conclude that the population is not mobile enough to have restored the balance of distribution of mature and young. This problem, as an important one from every standpoint, we have attacked by means of tagging experiments, by so-called "racial" studies of physical peculiarities, and by studies of growth, the results from which are seemingly in agreement. Returns from about ten thousand tagged fish

indicate that the younger fish are very much localized, hardly moving more than the width of the bank they are found on. The larger fish are also localized, but to a much lesser extent, for although the fish tagged north of Cape Spencer and those tagged south are showing but very little

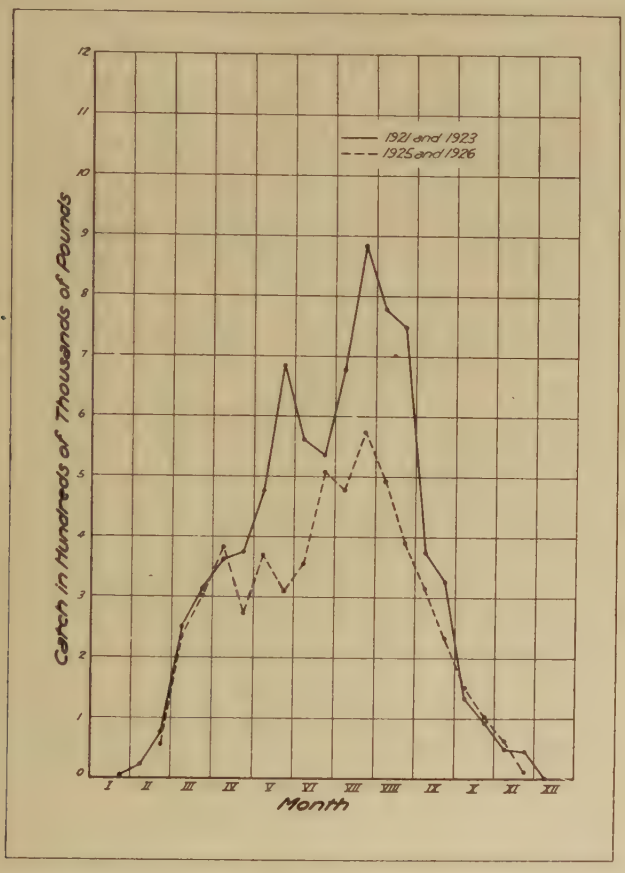


Plate 3. Catch of halibut from the older banks of Hecate Strait and Dixon Entrance, by two week periods, as hailed in Prince Rupert, showing characteristic summer fishery for immature. Unbroken line before, and broken line after, the closure of the winter season, November 16th to February 15th.

intermigration, the mature fish of the Gulf of Alaska show an active movement within their own region, perhaps connected with spawning. Details of this work must be awaited through future publications.

This lack of migration between the major divisions of the banks, even on the part of the mature large fish, has led us to believe that the spread

of the fishery to the westward has been into practically virgin banks. This is the more so in that the spread has been extremely rapid. Our records for the further removed banks extend as far back as 1912 and show that aside from catches of dense spawning schools, the average

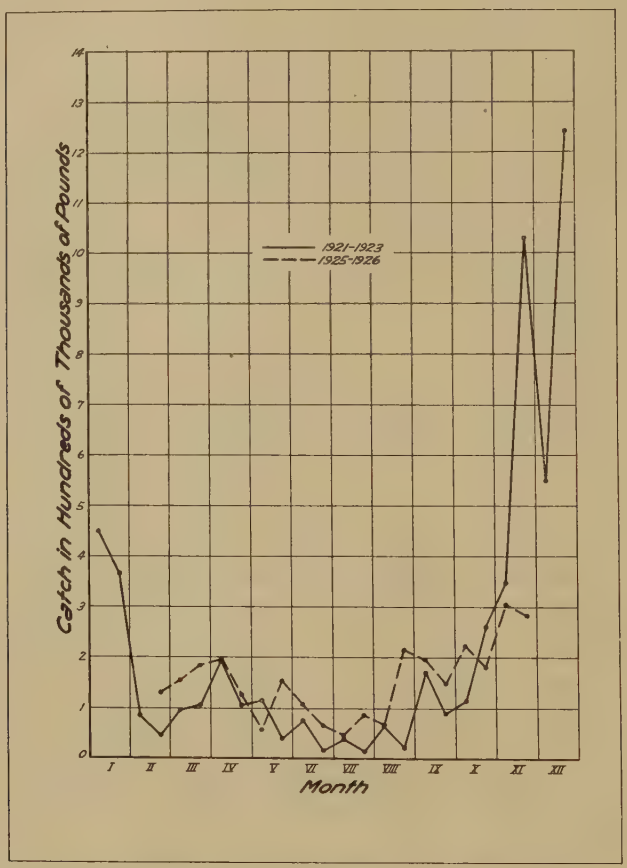


Plate 4. Catch of halibut from the Eastern side of the Gulf of Alaska by two week periods as hailed in Prince Rupert, showing characteristic winter catch of mature fish. Unbroken line before, and broken line after, the closure of the winter season, November 16th to February 15th.

yield per skate was never in excess of 150 pounds, as compared with the earlier maximal yield (in 1900 to 1904) of between 400 and 500 pounds on the grounds south of 56°. It becomes apparent, therefore, that under virgin conditions, the center of population of the halibut was upon these southern grounds but that the intense fishery has completely changed

this. The maximum yield is now being taken upon the far western grounds both as to total and as to catch per unit of gear. In fact, from a mass of detailed records of vessel operations it becomes apparent that the present abundance and the composition of the stock on any bank are functions of its distance from the landing ports and from the markets. It is plain that the dominant features in the distribution of the market-

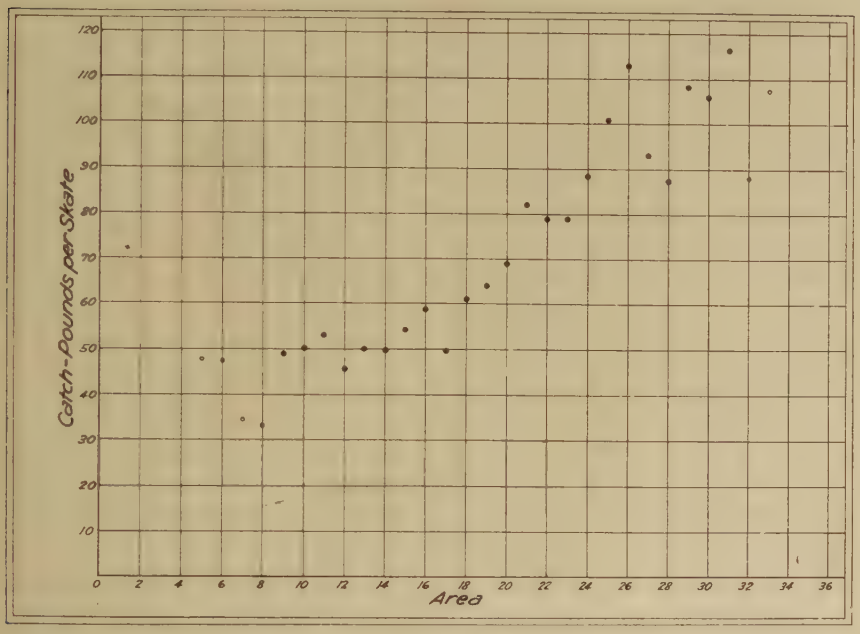


Plate 5. Variation in 1926 in catch per set of a unit of gear according to area. Each area comprises sixty linear miles of the trend of the coast, area 6 being off Cape Flattery and area 32 including the Shumagin Islands.

able halibut stock at present are not the result of biological factors, but rather of economic.

The intense fishery has indeed profoundly modified other aspects of the population. In common with the plaice fishery of the North Sea, and despite an effective size limit imposed by agreement between fishermen and dealers, we have found the percentage of small in the reduced total catch from the older grounds, to have increased very greatly, and the spawning grounds now known are on the more distant banks. A comparison of the rates of growth to show changes with time has not yet been made, but there is no reason why our samples, collected in 1914, when compared with present day material, should not throw light upon

this important matter. We do know, however, that the rate of growth on the southern, now depleted banks, is now, and has been since 1914, very much higher than that to the westward. Whether that is a result of the most productive (and first fished) banks presenting the best growth conditions, or a consequence of the removal of a large proportion of the fish from those banks to leave more food for the balance, is not known as yet, but our opinion inclines to the former. We do know, however, that even if it finally prove true that there is being substituted a catch of small, more rapidly growing fish for a densely schooled slow growth original catch, the annual total yield is not being maintained.

In view of these facts, especially those of the striking decline in total productivity and the enormous decline in the abundance of fish, it has seemed to the governments that the halibut fishery is in the position of a man who must go forward to live. Although we do not fear the biological death of the species, the question as to whether the halibut fishery, particularly on the southern banks is, or is capable of, remaining a great one, or is to become at best a small fraction of its present magnitude, seems about to be decided in favor of the latter answer.

There may, indeed, be no reason to doubt the possibility of an increased rate of replacement, due perhaps to an increased rate of growth and an increased rate of survival among either the old or the young fish. But admitting this does not involve any denial or disproof of the reality of overfishing, for the maximum good effect of thinning the population may have long ago been attained, particularly with regard to the older fish. The young of our halibut, meaning thereby fish of five to eight years of age, are found largely upon certain more or less well defined and isolated banks and do not seem to mingle generally with the larger fish. The banks upon which these larger fish have been taken are almost vacant. The most probable conclusion which we are able to reach is that the thinning of the banks holding larger fish was advantageous only up to a certain point, that this thinning has proceeded far beyond what could possibly have been advantageous and has taken on the aspect of the depletion of the proper breeding stock. The banks, especially those suitable for mature fish, are inhabited far too sparsely; the population of the older banks, were it double that now existent, could still find abundant nourishment, the rate of growth would not seriously suffer, and the safe yield would be far greater.

It is moreover of doubtful advantage to allow the present intense fishery to extend to the very young halibut, at present second and third grade in the market. It is a nice biological question, as to whether it is not better to have the young fish banks producing large numbers of

slow growth fish rather than a few rapid growth fish, in view of the favorable conditions they may meet as older fish. Nor have we any records which will show the effect of the present fishery upon the abundance of these small fish.

Under present conditions we find the intensity of the fishery to be increasing and to give promise of exceeding that which could logically have been expected, so that the banks will not be relieved of the pressure in the near future. It would seem under the present improvement of technical knowledge, with the use of power becoming constantly cheaper and materials becoming more readily available, that the efficiency of the fishery and the number of men engaged could increase almost indefinitely. The food produced is constantly more widely and generally distributed, and it may well be that the growth of the frozen packaged fillet trade will sooner or later bring even the very small halibut into great demand. The resultant great decline in the total landed from the older banks, and the enormous fall in the yield per unit of effort constitute disaster in themselves and are good reasons why, if they are to continue, the attempt to bring them to a halt should be immediately initiated.

The bringing of this decline in abundance to a pause implies, as a minimum, the prevention of any further increase in the intensity of the fishery, at least for adults. Stated in another way, the proportion of fish taken from the banks must not be allowed to continuously increase if the yield is to come to a position of stability. Granted that each unit of gear set takes a definite proportion of the fish from the ground upon which it is used, the prevention of any increase in the annual total number of sets of this gear must be tantamount to the maintenance of the present rate of removal. There should be, under prevailing conditions, no objection to the limitation of the fishery to its present intensity, thereby allowing the present fleet to exist — but there may well be objection to anything beyond this until it is demonstrated that whatever stable, permanent yield is ultimately obtained is a smaller one than should be. The Commission has therefore recommended that steps be taken to limit the present fishery on the older banks to its present magnitude, so that no greater proportion of the fish shall be taken until the abundance of fish on the banks becomes stabilized and as constant as possible in view of natural fluctuations. If it should so happen that the rates of growth and replacement do not increase, and the decline continues despite the action, there can be no alternative save to proceed to an actual restriction of the fishery.

This step of bringing the yield to a position of stability can be only

the first in rational scientific control of the halibut fishery. Although it would appear to be looking too far into the future from the practical political standpoint, the further problem follows of finding that level of abundance which is the most favorable one for the largest total yield. If, as is surmised, the rate of replacement for the present small population of marketable fish would be the same for a population twice or thrice as numerous, it would follow that allowing this population to increase to two or three times its present size would double or treble the present possible yield. The stock might be allowed to accumulate upon the banks until the thereby induced decline in rate of growth and the heightened mortality would balance the increased annual replacement due to the larger stock. Such an accumulation would be politically possible only if the present theories of the factors affecting the abundance of fishes under an intense fishery were replaced by actual facts acquired through experience. The regulation the Commission proposes, if backed by proper systems of observation, should lead to such knowledge of fact. It is moreover obvious that such an accumulation of the stock could be attained only over a considerable period of time, so that the fishermen would not be burdened too greatly by restriction. From a scientific standpoint, it would certainly require a number of years of careful observation to measure mathematically either the maintenance or the increase in this stock, in view of the natural variability in the annual increments now to be looked for in all species of fish. Finally, it is possible that biological conditions will intervene in unexpected ways, as for instance in case the position formerly occupied by the halibut has been preempted by other species; so that before it can be restored to its former abundance it may have to fight a battle for its place against enemies capable of just as stubborn resistance to increased mortality as is the halibut itself. So, in thus recommending the initial step in the rational control of the halibut fishery, the scientific staff is not unconscious of the long road that lies ahead, while it anticipates that the facts which such a step may bring to light may render that road a possible one.

This control is not yet provided for, and, however carefully granted, must be a power of flexible and direct regulation of the intensity of the fishery, whether the intensity is stated in terms of gear fished or proportion of stock removed. It is the function of the scientific staff to show the nature of these necessary regulations, and to so plan its work as to economically and efficiently provide this control with the necessary information which the executive must have, whether to guide his actions or to justify them to the public. Indeed, however crude the regulations

adopted, their effects must be properly observed, and this applies to the regulation at present in force. Under any conditions, a regulatory power seeking to control the halibut to the best advantage of mankind must look forward to a constant and long continued observation of

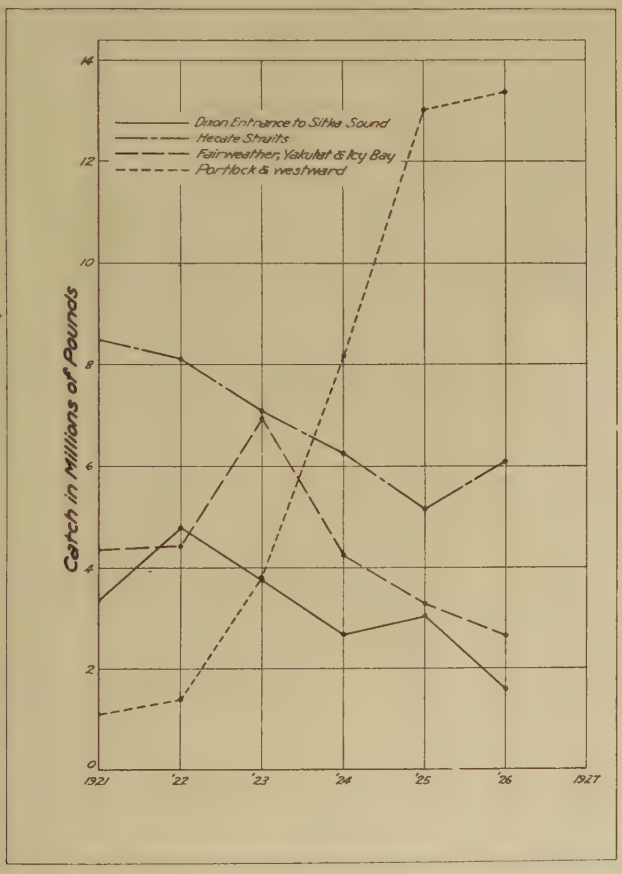


Plate 6. The rise in landings from the more distant banks including Portlock and westward, contrasted with the decline in those from other regions. Prince Rupert, 1921 to 1926 inclusive.

the rates of growth, of the abundance as artificially and naturally affected, and of the yield as well as of the composition of the stock. In short, the rational administration of the halibut fisheries involves the same careful mathematical methods that any engineer would utilize to obtain knowledge of a project with which he must deal. The regulation of the halibut must become a great experiment kept within politically possible

bounds, with the initiative in the hands of the executive using science and the scientist as sources of proper information.

The program of the scientific staff of the Commission has been framed as specifically and as thoroughly as possible from this standpoint. The longer adequate control is delayed, the more thorough should be the preparation for its coming, and the more inevitable it should be.

What tools then, must this scientific staff provide? Preeminent among these must be a system of observation, a system which gives more than a record of the total yield of halibut from each sector of the banks. There are three things essential, namely: first, records of abundance, based on a careful standardization of commercially used gear, since only by the use of commercial records can adequate data be acquired; second, records of total yield, by as small units as are possible in a deep sea fishery; third, estimates of the comparative intensity of the fishery, within these units. Were it possible for the staff to build from year to year a progressive graph containing three curves dealing with these phases, it believes that the problem of the ultimate effective control of the halibut fisheries would be infinitely nearer, since the rate of change in the productivity of the stock could be ascertained. It is regrettable that it has been possible to reconstruct but one of these curves, and that in an approximate way only from past records.

In the consideration of the significance of these records once they are obtained, and in their application, the factor of dominating importance, without doubt is that of the relative independence of the banks. From an inspection of the biological and statistical facts thus far gathered there is plainly a very considerable degree of such independence. Depletion has proceeded seemingly as a more or less independent process on different parts of the coast, and has carried the level of abundance very much lower on some banks than others. There is, also, good ground for believing that the initial levels of abundance were very different. Work has proceeded actively to determine the exact extent of this independence during the stages from the first settlement on the bottom until maturity is attained. But the administrator, contemplating the regulation of various sections of the coastal banks, and utilizing for that purpose the records obtained by observation of the catch, must ultimately find that the reaction of the stock to the intensity of the fishery will be conditioned by the source of the eggs and larvae. Presumably the maintenance of a stock of mature fish upon every bank would care adequately for the production of young, regardless of where the eggs and larvae drifted, but we have already gone far enough in our knowledge of the fishery to know that certain sectors of the coast in combination pro-

bably form biological units, a fact which will necessitate the correlation of protective measures on different banks in order that a given population may exist. Thus the banks on the eastern side of the Gulf of Alaska may be spawning grounds for others far to the westward and the opening of either the westward or eastward banks to unrestricted exploitation may be fatal to the purposes of the administrator. Our experience with the movements of the adults up to the present writing does not encourage us in the belief that the results therefrom will finally result in as perfect a picture of these "biological units" as may be necessary. Our study of the migration of the bottom stages is therefore being extended to include the drifting larvae, with the hope that we shall thereby secure a more perfect basis of knowledge upon which regulation can be based. We feel that regulation can and will proceed without a detailed picture of the migrations of the younger stages, since it should suffice to follow an adult population through its life and movements, protecting it so that a proper number of spawners are produced. But the more complete the facts the more ready the justification, and the clearer the reasoning.

It would almost seem as though knowing the rate of movement of young and adults, the drift of the eggs and larvae, the course of the fishery, and its effect upon the stock within each area, that the problem of the administrator would then lie clearly before him. Such, however, does not seem to be the case, as nearly as we may judge from the reception that proposed regulations have had. To apply and retain his regulations, to defend their retention, to judge their results, he must know the rate at which the various processes of replacement proceed. He must know the rapidity of growth, the time and age at which the fish enter the commercial catch, the natural variability of the annual increments, the composition of the various populations and the spawning times. He must be informed as to the time it requires for the trustworthy determination of a trend in his statistics, considering them from the mathematical standpoint. In short, he must have a proper perspective as to the time taken by the processes with which he deals and as to the form their results will take when they become evident. It is perhaps too much to hope that the importance of such knowledge will be appreciated before the actual facts are thrust into view. The staff of the Commission has therefore made what contributions it has found possible to these phases, especially as they become evident throughout much of the data gathered for purposes already outlined.

The breadth of view which such facts give is necessary both to the statistician and to the administrator. They are what are commonly

termed biological facts, and justify the approach to the problem of the halibut from the biological standpoint.

In these pages it has been attempted to outline the program of the scientific staff of the Commission as it should exist under ideal conditions. But the Commission has naturally been anxious that its decisions as to necessary regulations should not be deferred too long, that the permanent program of the Commission should be gotten under way as soon as possible. To that end it has required of the staff that from the data obtained during the first few years the first conclusions should be drawn as quickly as possible without awaiting the publication of the detailed results. This has been done, and the report of the Commission with its recommendations has been presented to the two governments of the United States and Canada, and has been issued as a publication by the Canadian government. These recommendations form the basis upon which a regulatory power may vary the intensity of the fishery and put into effect adequate methods of observation as to the results. They insist upon the essential character of the control of the intensity of the fishery, whether through the limitation of the total catch or otherwise. The recommendations of the Commission are plainly not a statement of final findings, but rather of the program which must be followed.

This report of the Commission also deals with the specific regulation imposed by the treaty, the close season of three winter months. The consideration of this close season brought clearly to attention the necessity of the Commission's program of statistical and biological research as an aid to the executive. It was necessary to gather statistical evidence of the course of the fishery as far back as possible, that changes in it might be known. It was exceedingly fortunate that this could be done in even a partial fashion. The close season was shown to apply to the spawning fish alone and to a fishery which was at that season largely concentrated in one locality, one of the less depleted. As a consequence the relationship of the fish there taken to the stock on other banks was investigated and the fact substantiated that these mature fish were taken during the summer predominately on banks to the west but only in minor degree to the south. The statistics of the catch necessary were obtained area by area and were related directly to biological studies of migration. Finally, although the immediate effects of the closure were to be seen clearly enough, as ineffective in nature, it was necessary to acknowledge that had these immediate effects been of a useful character, the final result in terms of increased abundance and changed composition of the stock could only have been detected over

a period of time sufficiently great to have allowed for the rates of growth and the natural variability of the species.

It follows, from the fact that statistical and biological work of the character described in these pages, was necessary to judge as to the effect of this measure, that the same type of information will be necessary in the future, whether a specific regulation is under review or not. Whether the fishery is without restraint or is regulated, it will never be known what is happening unless a scientifically organized system of statistical and biological observation is in operation.

Die Verwendung von Stickstoff- und Sauerstoffanalysen in der Meeresforschung.

Von

Kurt Buch.

Institut für Meeresforschung, Helsingfors, Finnland.

In den ersten Jahren des Bestehens der Internationalen Meeresforschung wurden auf den hydrographischen Terminfahrten regelmässige volumenometrische Bestimmungen von sowohl Sauerstoff als auch freiem Stickstoff ausgeführt. Dem letzten wurde Bedeutung beigelegt, weil man nach den, ursprünglich von Tornoe und Oscar Jacobsen[1]) ausgesprochenen Behauptungen der Meinung war, dass man aus dem Stickstoffgehalte einer Wasserprobe, welche oft beträchtlich vom Sättigungsgehalte abwich, berechnen könnte, bei welcher Temperatur die betreffende Wasserprobe sich ursprünglich an Stickstoff gesättigt hatte. Martin Knudsen[2]) wies dann nach, dass solch eine Berechnung nicht zu richtigen Ergebnissen führen kann, weil eine Wasserschicht im Meere stets durch vielmalige Mischung verschiedener Wasserschichten mit verschiedenen Temperaturen und Salzgehalten entstanden ist, wodurch die Verhältnisse sich so komplizieren, dass irgendwelche Schlüsse über einen Anfangszustand nicht möglich sind. Hiernach wurden die an und für sich auch lästigen volumenometrischen Bestimmungen gänzlich aufgegeben und fortan nur der Sauerstoff nach der bedeutend einfacheren Titrationsmethode von Winkler-Bjerrum bestimmt.

---

[1]) Tornoe. Ref. von O. Pettersson und G. Ekman. Grunddragen av Skageracks och Kattegats hydrografi. — Kungl. Sv. Vetensk. Akad. Handl. Bd. 24. No. 11. 1891. S. 7.

Oscar Jacobsen. Ueber die Luft des Meerwassers. — Ann. d. Chemie und Pharmacie. Bd. CLXVII. 1873. S. 22. Ref. Martin Knudsen, siehe folgende Fussnote.

[2]) Martin Knudsen. Ueber den Gebrauch von Stickstoffverbindungen in der Hydrographie. — Conseil permanent pour l'exploration de la mer. Publications de Circonstance. No. 2. 1903.

Martin Knudsen's damalige Kritik betraf nur die erwähnte Berechnungsmethode in betreff der Temperatur, keineswegs aber die hydrographische Verwendbarkeit der Stickstoffbestimmungen in eventuell anderer Weise. Trotzdem haben dieselben seitdem ihre Aktualität vollständig eingebüsst.

Nun sind ja die allgemeinen hydrographischen Ursachen der Variationen im Sättigungsgrade des Wassers an Gasen, sowie Einfluss der Temperatur, der Mischung vom Wasser verschiedenen Salzgehaltes und verschiedener Temperatur wohlbekannt; und man kann diese Einflüsse gerade an dem von biologischen Einwirkungen so gut wie unabhängigen Stickstoff in vielen Fällen gut überblicken. Aber ein Rückschluss hieraus auf die hydrographischen Verhältnisse stösst infolge der erwähnten Kompliziertheit der Verhältnisse auf Schwierigkeit.

Im folgenden soll nun gezeigt werden, dass desungeachtet auch die Stickstoffbestimmungen ein hydrographisch ausnutzbares Material darbieten, welches zur Klärung verschiedener noch unbeantworteter Fragen beitragen kann, wenn man nämlich die Resultate der Stickstoffbestimmungen mit denen der Sauerstoffbestimmungen kombiniert.

Der jeweils vorhandene Sauerstoff des Wassers ist einerseits abhängig von physikalischen Wirkungen, nämlich vom Gasaustausch mit der Atmosphäre und den unablässigen Veränderungen, die durch Mischungen und Temperaturvariationen hervorgebracht werden. Andererseits ist der Sauerstoff abhängig vom Einfluss der Tier- bezw. Pflanzenorganismen des Wassers, welche Sauerstoff zehren bzw. erzeugen. In der Tiefe ist nur der zehrende Faktor zugegen, weshalb Tiefenwasser wie bekannt um so weniger Sauerstoff enthält, je längere Zeit es von der Verbindung mit der äusseren Atmosphäre abgeschnitten gewesen ist. Das so durch den Sauerstoffgehalt gemessene, relative »Alter« eines Wassers wird seit langem als ein wichtiger hydrographischer Faktor anerkannt. Als Mass desselben hat man bisher den sogen. Sauerstoffprozentgehalt angewandt, d. h. das hundertfache Verhältnis des analytisch bestimmten Gehaltes und des Gehaltes, welcher vorhanden wäre, wenn das Wasser bei der vorhandenen Temperatur und dem vorhandenen Salzgehalte genau an Sauerstoff gesättigt wäre. Leider gibt dieses Mass nur ein unvollständiges und ganz relatives, oft auch ein falsches Bild von der wirklichen Zehrung und kann nur zur Beurteilung eines statischen Zustandes angewandt werden, bedeutet aber auch in dieser Hinsicht kaum mehr als die direkt ermittelten Sauerstoffgehaltzahlen allein. Aber über Fragen z.B. der Zeitdauer der Isolation und den daraus zu folgernden Schlüssen über die Strömungsgeschwindigkeit der einzelnen Wasserschichten kön-

nen wir erst Aufschluss erhalten, wenn wir experimentell einen quantitativen Zusammenhang zwischen Sauerstoffzehrung und der dieselbe beeinflussenden einzelnen Faktoren, wie die Menge der atmenden Organismen und die Temperatur, nachweisen können. Überhaupt ist das ganze Problem der Sauerstoffzehrung sowohl biologisch als hydrographisch von grossem Interesse, es ist aber bisher so gut wie unbearbeitet geblieben.

Ein Umstand, der für die Förderung der Frage sehr hinderlich gewesen ist, ist gerade die Schwierigkeit, eine stattgefundene Zehrung quantitativ feststellen zu können. Wir können sagen, wie viel unter- oder übersättigt das Wasser bei einem gegebenen Zustand ist. Abweichungen vom Sättigungszustande kommen aber auch durch die physikalischen Einflüsse zustande. Um diese und die biologischen von einander trennen zu können, müsste man den »ursprünglichen Sauerstoffgehalt« kennen, mit welchem wir den Sauerstoffgehalt bezeichnen wollen, welcher vorhanden wäre, wenn keine biologische Einwirkung stattgefunden hätte. Hierzu kann uns nun, wie im folgenden gezeigt werden soll, der Stickstoffgehalt des Wassers verhelfen, der ja als von biologischen Veränderungen praktisch unberührt angesehen werden kann[1]).

Die Löslichkeit des Stickstoffs und des Sauerstoffs im Wasser ist verschieden, und variiert bekanntlich stark mit dem Salzgehalte und der Temperatur. In bezug auf den Verlauf der Variationen verhalten sich jedoch beide Gase verhältnismässig übereinstimmend, so dass das Verhältnis der Absorptionskoeffizienten Abskoeff. O_2/Abskoeff. N_2[2]) verhältnismässig wenig mit Temperatur und Salzgehalt variiert. Lassen wir die Verschiedenheit der Diffusionsgeschwindigkeit des Stickstoffs und des Sauerstoffs unbeachtet[3]), so werden also, solange keine biologische Einwirkung stattfindet, die durch die physikalischen Einwirkungen bedingten Veränderungen des Sättigungsgrades an Stickstoff und Sauerstoff parallel verlaufen, und in Anbetracht dessen, dass der N_2-gehalt des Wassers stets nur wenig vom Sättigungsgehalte abweicht, werden wir keinen sehr grossen Fehler begehen, wenn wir

---

[1]) Der Gehalt an mineralischen Stickstoffverbindungen wie NH_3, NO'_3 und NO'_2 übersteigt ja meist nicht ein paar hundert mg pro m^3. Die mögliche Bildung von Stickstoff durch Denitrifikation (oder Oxydation von NH_3), möglicherweise auch Zersetzung von NH_4NO_2 kann den freien Stickstoff um Mengen erhöhen, die von ganz untergeordneter Bedeutung sind. Verminderung an N_2 durch die Einwirkung stickstoffbindender Bakterien ist auch möglich. Bakterien dieser Art sind bisher jedoch ausschliesslich in unmittelbarer Küstennähe beobachtet.

[2]) Mit Absorptionskoeffizient bezeichnen wir die in cm^3 (0°, 760 mm) gemessene Menge Sauerstoff bzw. Stickstoff, die 1 l. Meerwasser im Gleichgewicht mit der Atmosphäre vom Normaldruck 760 mm enthält.

[3]) Bekanntlich spielt ja die Diffussion im Meere eine ganz untergeordnete Rolle.

die Sättigungsverhältnisse als auch für die uns unbekannten tatsächlichen Verhältnisse O_2/N_2 gültig betrachten. Wenn wir die Verhältnisse zwischen den Absorptionskoefficienten für O_2 und N_2, welch letztere wir den Tabellen von Chas. J. J. Fox[1]) entnehmen, ein für allemal berechnet haben, so ergibt sich also der Sauerstoffgehalt bei bestimmter Temperatur und bestimmtem Chlorgehalt aus dem Stickstoffgehalte durch Multiplikation mit der entsprechenden Verhältniszahl.

Nun stimmen aber die gefundenen *in situ* geltenden N_2-, Cl- und Temperaturzahlen nicht genau mit den entsprechenden zusammengehörenden Zahlen in den Tabellen überein, da das Untersuchungswasser nicht genau gesättigt ist. Also sind wir gezwungen, eine der drei *in situ* geltenden Zahlen zu ignorieren. Ausgeführte Kalkulationen ergaben, dass dies nicht mit dem Stickstoff geschehen darf, weil der prinzipielle Fehler der Methode hierbei zu sehr ins Gewicht fallen würde. Wir verfahren dann praktisch entweder so, dass wir aus der Stickstofftabelle unter Ignorierung der gemessenen Temperaturzahl diejenige Temperaturzahl aufsuchen, welche der gefundenen Chlor- und Stickstoffzahl des Meerwassers entspricht. Wenn wir letztere mit der Verhältniszahl O_2/N_2 multiplizieren, die der aufgesuchten Temperatur und der gefundenen Chlorzahl entspricht, erhalten wir die gesuchte Sauerstoffzahl[2]). Oder auch suchen wir unter Ignorierung der gefundenen Cl-Zahl die Cl-Zahl der Tabelle, welche der gemessenen Temperatur und der gefundenen Stickstoffzahl entspricht, und entnehmen die Sauerstoffzahl in derselben Weise. Beide Verfahren sind prinzipiell gleich berechtigt. Die ausgeführten Kalkulationen ergaben aber für das erste durchschnittlich mit den tatsächlichen Verhältnissen besser übereinstimmende Werte, weshalb für die folgende Darstellung nur dieses Verfahren angewandt wurde. Die Anwendung beider Verfahren und Benutzung des Durchschnittswertes verkleinerte die Fehler nicht.

Die Tabelle 1 enthält die Quotienten O_2/N_2, berechnet aus den in bezug auf Temperatur und Chlor einander entsprechenden Stickstoff- und Sauerstoffzahlen der Tabellen von Fox, der Bequemlichkeit halber

---

[1]) Chas. J. J. Fox. On the coefficients of absorption of the atmospheric gases etc. Part I. Conseil permanent international pour l'exploration de la mer: Publications de Circonstance No. 41.

Erratum to Publication de Circonstance No. 41.

[2]) Das Verfahren ist prinzipiell identisch mit der von Tornoe angeführten Methode, die Temperatur zu bestimmen, bei welcher das Wasser ursprünglich an Stickstoff gesättigt gewesen war, und welches von M. Knudsen als falsch bewiesen wurde. Zur Temperaturbestimmung ist es allerdings nicht anwendbar. Aber der »biologisch unbeeinflusste Sauerstoff« wird nach den weiter unten angeführten Mischungsbeispielen zu urteilen mit sehr guter Annäherung wiedergegeben.

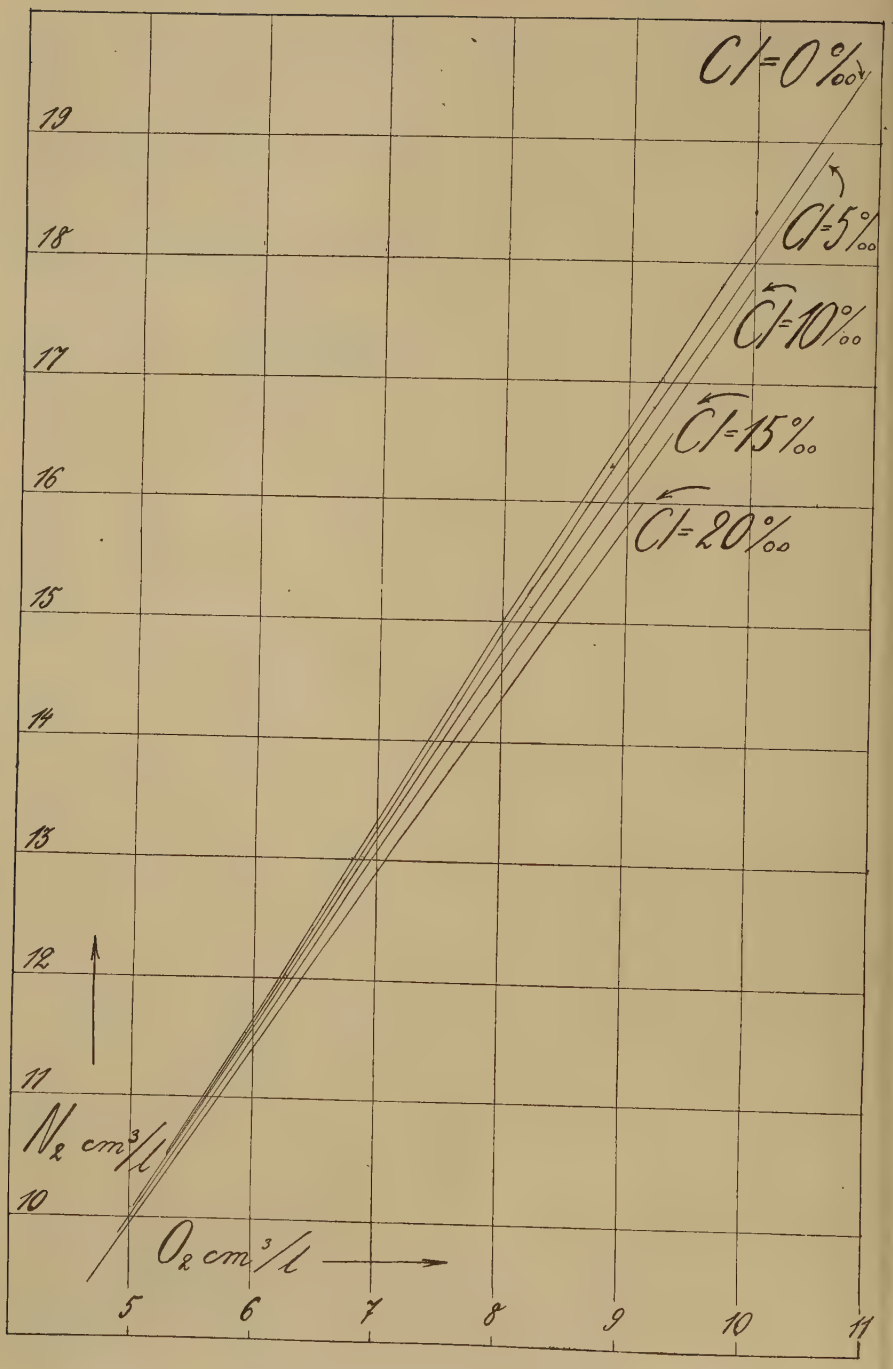

Cl=0‰
Cl=5‰
Cl=10‰
Cl=15‰
Cl=20‰
19
18
17
16
15
14
13
12
11
10
N2 cm3/l
O2 cm3/l
5
6
7
8
9
10
11

Tabelle 1.

N_2 cm³/l	$O_2 : N_2$ bei verschiedenen Cl ‰				
	Cl = 0	5	10	15	20
19.5	0.557	..	..	..	..
19.0	.554	(0.562)	..	..	..
18.5	.552	.559	..	..	..
18.0	.549	.556	(0.565)	..	..
17.5	.547	.553	(.561)	..	..
17.0	.544	.550	.558	(0.569)	..
16.5	.541	.547	.554	(.565)	..
16.0	.539	.544	.551	.561	(0.574)
15.5	.536	.541	.547	.556	.569
15.0	.534	.538	.544	.552	.564
14.5	.531	.535	.540	.548	.558
14.0	.529	.532	.537	.544	.553
13.5	.527	.529	.534	.540	.548
13.0	.524	.526	.530	.535	.543
12.5	.522	.523	.527	.531	.538
12.0	.519	.520	.523	.527	.532
11.5	.514	.516	.519	.522	.527
11.0	.508	.510	.513	.517	.522
10.5	..	.502	.505	.510	.514
10.0	..	..	.493	.499	.504
9.5	..	..	..	..	.491

mit den Stickstoff und Chlorzahlen als Argumenten. Noch einfacher gestaltet sich die Berechnung graphisch mit Hilfe des Diagrammes Fig. 1, das die Stickstoffzahlen als Ordinaten und die Sauerstoffzahlen als Abscissen enthält, und welches, da die Punkte gleichen Chlorgehalts durch fast gerade Linien verbunden sind, einfache Interpolation zwischen den Chlorlinien gestattet[1]).

Die nach dem angegebenen Verfahren berechnete Sauerstoffzahl soll also denjenigen Sauerstoffgehalt angeben, der im Wasser vorhanden wäre, wenn keine biologische Einwirkung stattgefunden hätte. Wir wollen ihn »den biologisch unbeinflussten Sauerstoff« nennen und mit O_2^N bezeichnen.

[1]) Fast ebenso berechtigt ist das System, das Punkte gleicher Temperatur mit einander verbindet. Aber die Werte, die die Interpolation hierbei ergibt, stimmen, wie schon vorher erwähnt, nicht ganz so gut wie bei der ersten Methode mit den tatsächlichen Verhältnissen überein. — Zur praktischen Anwendung muss das Diagram Fig. 1 auf Millimeterpapier im Masstabe 1 cm³ N_2 bzw O_2 = 5 cm aufgetragen werden.

Wir wollen nun an der Hand einer Anzahl Rechenbeispiele ermitteln, wie zuverlässig diese berechneten Sauerstoffzahlen sind und in welcher Weise verschiedene Faktoren einwirken, und zwar wollen wir zuerst den Einfluss allein der Temperaturveränderung auf den Sättigungsgrad an Stickstoff, Sauerstoff und auf den Quotienten untersuchen. Sodann wollen wir an Mischungsbeispielen zeigen, wie der tatsächliche Sauerstoffgehalt einer aus bekannten Komponenten entstehenden Wassermischung mit dem aus dem Stickstoffgehalte der Mischung in angegebener Weise berechneten Sauerstoffgehalt übereinstimmt. Die Mischungsbeispiele wurden so gewählt, dass zuerst an zwei Wasserproben gleichen Salzgehaltes und verschiedener Temperatur, die zu gleichen Teilen gemischt wurden, der Einfluss der Temperatur, und sodann an Proben gleicher Temperatur und verschiedenen Salzgehaltes der Einfluss des Salzgehaltes untersucht wird. Schliesslich werden auch Mischungsbeispiele, bei denen sowohl Salz als Temperatur variieren, angeführt. Die Variationen wurden extrem gewählt, mit grösseren Differenzen als sie in Wirklichkeit vorkommen, sodass die Abweichungen der berechneten und tatsächlichen Sauerstoffgehalte von einander in der Natur kleiner als in den hier angeführten Beispielen sein werden. Es wird angenommen, dass die Komponenten bei der angegebenen Temperatur und dem angegebenen Salzgehalte mit den bez. Gasen gesättigt sind. Der Salzgehalt wird durch die Chlorzahl angegeben, weil die Tabellen von Fox mit dieser als Argument aufgestellt sind.

Temperatureinfluss.

Erwärmung eines bei niedriger Temperatur mit Luft gesättigten Wassers bewirkt, wie bekannt, Uebersättigung, und Abkühlung Untersättigung. Der Gehaltsquotient O_2/N_2 bleibt dagegen unverändert, weshalb eine weitere Erläuterung nicht vonnöten ist. Um jedoch die Veränderung des Sättigungsgrades bei einer Temperaturveränderung um 20° zu zeigen, seien die Sättigungsgehalte bei 20° und 0° einer Wasserprobe mit Cl = 0 ‰ und einer Probe mit Cl = 20 ‰ angeführt.

Cl-Gehalt		Temp.	O_2 cm³/l	N_2 cm³/l	O_2/N_2	Sättungsgrad in Prozent	
						O_2	N_2
0 ‰	Vor Temp.-Veränd.	0	10.29	18.64	0.552	100	100
	Nach —	20	»	»	»	156.6	148.1
	Vor —	20	6.57	12.59	0.522	100	100
	Nach —	0	»	»	»	63.8	67.5
20 ‰	Vor Temp.-Veränd.	0	7.97	14.31	0.557	100	100
	Nach —	20	»	»	»	150.1	138.1
	Vor —	20	5.31	10.36	0.513	100	100
	Nach —	0	»	»	»	66.6	72.4

Die Zahlen ergeben, dass die Sättigungsgrade von O_2 und N_2 nach vorgenommener Temperaturveränderung nicht mehr gleich sind, obgleich das Verhältnis des tatsächlich vorhandenen Sauerstoffs und Stickstoffs O_2/N_2 unverändert bleibt.

Mischungsbeispiele.

Die Zusammensetzung der Mischungskomponenten und der Mischungen geht aus den folgenden Zusammenstellungen hervor. Zum Vergleich werden nebst den durch Mischung entstehenden Gehalten an O_2 und N_2 auch die Gehalte angegeben, die das Wasser hätte, wenn es unter gleichen Temperatur- und Chlorbedingungen gesättigt wäre, sowie auch die Sättigungsgrade in Prozenten.

Mischungsbeispiel No. I	Wasser A $t = 0°$, $Cl = 0\ ‰$	Wasser B $t = 20°$, $Cl = 0\ ‰$	$^1/_2$ (A + B)	$t = 10°$, $Cl = 0\ ‰$	
			gemischt	gesättigt	Sättigungsprozent
O_2 cm³/l	10.29	6.57	8.43	8.02	105.1
N_2 cm³/l	18.64	12.59	15.61	15.02	103.9
O_2/N_2	0.552	0.522	0.540	0.534	—

Sauerstoffgehalt O_2^N berechnet aus N_2 durch Interpolation aus Tabelle 1: $O_2^N = 15.61 \times 0.536 = 8.39$ cm³/l. Fehler als Differenz des berechneten und tatsächlichen Wertes: 8.43—8.39 = 0.4 cm³/l, oder 0.5 %.

No. II	Wasser A $t = 0°$, $Cl = 20\ ‰$	Wasser B $t = 20°$, $Cl = 20\ ‰$	$^1/_2$ (A + B)	$t = 10°$, $Cl = 20\ ‰$	
			gemischt	gesättigt	Sättigungsprozent
O_2 cm³/l	7.97	5.31	6.64	6.35	104.6
N_2 cm³/l	14.31	10.36	12.34	11.94	103.4
O_2/N_2	0.557	0.513	0.538	0.532	—

$O_2^N = 12.34 \times 0.536 = 6.62$ cm³/l; Fehler 6.64 −6.62 = 0.2 cm³/l = 0.3 %.

No. III	Wasser A $t = 0°$, $Cl = 0\ ‰$	Wasser B $t = 0°$, $Cl = 20\ ‰$	$^1/_2$ (A + B)	$t = 0°$, $Cl = 10\ ‰$	
			gemischt	gesättigt	Sättigungsprozent
O_2 cm³/l	10.29	7.97	9.13	9.13	100.0
N_2 cm³/l	18.64	14.31	16.475	16.47	100.0
O_2/N_2	0.552	0.557	0.554	0.554	—

$O_2^N = 16.475 \times 0.554 = 9.13$, Fehler 0.0 %.

No. IV.	Wasser A t = 20°, Cl = 0 ‰	Wasser B t = 20°, Cl = 20 ‰	½ (A + B)	t = 20°, Cl = 10 ‰	
			gemischt	gesättigt	Sättigungsprozent
O_2 cm³/l.....	6.57	5.31	5.94	5.95	99.8
N_2 cm³/l.....	12.59	10.36	11.475	11.47	100.0
O_2/N_2.....	0.522	0.513	0.518	0.519	—

$O_2^N = 11.475 \times 0.519 = 5.95$ cm³/l; Fehler 0.2 %.

No. V.	Wasser A t = 26°, Cl = 0 ‰	Wasser B t = 26°, Cl = 20 ‰	½ (A + B)	t = 26°, Cl = 10 ‰	
			gemischt	gesättigt	Sättigungsprozent
O_2 cm³/l.....	5.94	4.78	5.36	5.37	99.8
N_2 cm³/l.....	11.54	9.65	10.595	10.60	100.0
O_2/N_2.....	0.515	0.495	0.506	0.507	—

$O_2^N = 10.595 \times 0.506 = 5.36$ cm³/l; Fehler 0.0 %.

No. VI.	Wasser A t = 0°, Cl = 0 ‰	Wasser B t = 20°, Cl = 20 ‰	½ (A + B)	t = 10°, Cl = 10 ‰	
			gemischt	gesättigt	Sättigungsprozent
O_2 cm³/l.....	10.29	5.31	7.80	7.19	108.5
N_2 cm³/l.....	18.64	10.36	14.50	13.47	107.6
O_2/N_2.....	0.552	0.513	0.538	0.534	—

$O_2^N = 14.50 \times 0.540 = 7.83$ cm³/l; Fehler 0.4 %.

No. VII.	Wasser A t = 0°, Cl = 20 ‰	Wasser B t = 20°, Cl = 0 ‰	½ (A + B)	t = 10°, Cl = 10 ‰	
			gemischt	gesättigt	Sättigungsprozent
O_2 cm³/l.....	7.97	6.57	7.27	7.19	101.1
N_2 cm³/l.....	14.31	12.59	13.45	13.47	99.6
O_2/N_2.....	0.557	0.522	0.541	0.534	—

$O_2^N = 13.45 \times 0.534 = 7.18$ cm³/l; Fehler 1.2 %.

Betrachten wir nun die Zahlen der Zusammenstellung, so können wir in bezug auf die nach dem beschriebenen Prinzip aus den Stickstoffzahlen berechneten Sauerstoffzahlen folgendes feststellen:

1) Mischungen von Wasser verschiedenen Salzgehaltes, aber gleicher

Temperatur, ergeben einen berechneten Sauerstoffgehalt O_2^N, der fast exakt mit dem tatsächlichen übereinstimmt.

2) Mischungen von Wasser gleichen Salzgehaltes, aber verschiedener Temperatur geben bei einer Temperaturdifferenz der Komponenten von 20° (0°—20°) einen 0,5 % des Sauerstoffgehaltes nicht übersteigenden Fehler.

3) Bei den Mischungsbeispielen, in denen sowohl Temperatur als Cl der Komponenten verschieden sind, erhalten wir etwas grössere Fehler, in den angeführten Fällen bis 1,2 %. Vergleichen wir die gewählten Beispiele mit den in der Natur vorhandenen Verhältnissen, so finden wir dort nie Temperaturveränderungen und unmittelbare Mischungen mit so extrem zusammengesetzten Komponenten wie in den Beispielen. In der Natur mischt sich eine Schicht mit einer unbedeutend verschieden zusammengesetzten Nachbarschicht, das neue Gemisch wiederum mit einem nur etwas von diesem abweichenden und so weiter. Die bei jeder Mischung entstehenden kleinen Fehler können sich auf diese Weise häufen, und man kann zu ungefähr ähnlichen Ergebnissen kommen wie wenn man zwei mehr extrem zusammengesetzte Wasserproben unmittelbar mischt. Doch auch bei Beachtung dieses Umstandes finden wir beim Betrachten der Beispiele, dass wir in der Natur nicht grössere Variationen als in diesen Beispielen zu erwarten haben. Im Ozeanwasser, wo fast nur Temperatureinflüsse von Bedeutung sind, kann der Fehler 0,5 % nicht übersteigen. Die angeführte maximale Rechenunsicherheit ist nicht grösser als die Analysenunsicherheit.

Insgesamt scheinen uns also die angeführten Kalkulationen zu erlauben, die Genauigkeit des Verfahrens zur Feststellung von O_2^N als befriedigend zu betrachten und somit die Einführung des Begriffes des biologisch unbeeinflussten Sauerstoffs als genügend begründet anzusehen. Eine definitive Bewertung ist jedoch erst möglich bei der Anwendung auf die Verhältnisse in der Natur. Wie schon oben erwähnt, bezweckt die Grösse O_2^N einen Ausgangswert zur Bestimmung der Sauerstoffzehrung darzustellen, die sich als Differenz dieser Zahl und des im Meere gefundenen Sauerstoffgehaltes, $O_2^N - O_2$, ergibt. Diese Differenz kann sowohl positive als negative Werte annehmen. Im ersten Fall hat der sauerstoffzehrende Einfluss der Tierorganismen die Produktion von Seiten der Pflanzenorganismen überwogen, im letzten hat die Assimilation überwogen. Die weitere Anwendung mag an einem Beispiel erläutert werden: Eine im August im Skagerrak aus 20 m Tiefe geschöpfte Wasserprobe (Temp. 6,93°, Cl = 19,26 ‰) enthielt 13,57 cm³/l N_2 und 7,26 cm³/l O_2. O_2^N berechnet aus N_2 = 7,44 cm³/l, $O_2^N - O_2$ = 0,18 cm³/l. Berechnen wir aber aus den gegebenen Temperatur- und Chlorzahlen

den Sättigungsgehalt O'_2, der vorhanden wäre, wenn das Wasser unter den gegebenen Bedingungen genau gesättigt wäre, so erhalten wir $O'_2 = 6{,}84$. Das Wasser war also gemäss $O'_2 - O_2 = -0{,}42$ im Verhältnis zur normalen Atmosphäre an Sauerstoff übersättigt. Trotzdem haben wir feststellen können, dass es an Sauerstoff verloren hat. Die naheliegende Erklärung ist die, den Sauerstoffschwund biologischen und die gleichzeitige Übersättigung physikalischen Umständen zuzuschreiben. So gestattet uns das Verfahren, diese beiden Einwirkungen gleichzeitig zu verfolgen und gegen einander abzuwägen.

Die Zehrungszahl $O_2^N - O_2$ besagt nicht immer, wie viel in Wirklichkeit gezehrt worden ist, sondern nur wie viel weniger Sauerstoff das Wasser enthält, als wenn keine biologische Einwirkung stattgefunden hätte. Liegt z. B. eine Oberflächenwasserprobe vor, die durch biologische Zehrung ein wenig untersättigt, aber an Stickstoff übersättigt ist, so hat das Wasser seit einer gewissen Zeit aus der Atmosphäre Sauerstoff aufgenommen und Stickstoff abgegeben. Die Zehrungszahl $O_2^N - O_2$ wird in diesem Falle kleiner als die tatsächliche Zehrung. Trotzdem stellt sie ein relatives mit der Intensität der Zehrung parallel vorlaufendes Mass dar. In der Tiefe gibt sie den tatsächlichen Sauerstoffschwund getreuer wieder und ist jedenfalls ein zuverlässigeres Mass zur Beurteilung des »Alters« eines Wassers für hydrographische Zwecke, als der jetzt gebräuchliche Prozentgehalt $100 \times O_2/O'_2$. Man kann auch die Zehrung in Prozenten darstellen durch den Ausdruck $100 \times O_2/O_2^N$. Diese Ausdrucksweise bietet den Vorteil, dass die Analysenfehler der Stickstoff- und Sauerstoffbestimmungen weniger ins Gewicht fallen, als bei der Darstellung der Zehrung in Form einer Differenz. Es wird demnach für die praktische Verwertung der Bestimmungen zweckmässig sein, beide Ausdrucksweisen anzuwenden.

Es ist nun noch darzulegen, welche Genauigkeit wir in der Darstellung der Sauerstoffzehrung $O_2^N - O_2$ erlangen können. Diese ist ausser von der angeführten Genauigkeit des Rechenverfahrens selbst naturgemäss auch von der Analysengenauigkeit der Stickstoff- und der Sauerstoffbestimmung abhängig. Zur Beleuchtung des letzten seien eine Anzahl von Sigurd Stenius[1]) ausgeführter Doppelanalysen nach dem Auskochverfahren mit dem Apparat von O. Pettersson von Wasserproben[2]) der Finnland umgebenden Meere aus den Jahren 1898—1903 angeführt:

[1]) Finnländische hydrographisch-biologische Untersuchungen No. 1, Helsingfors 1907, S. 55—57 und 128—131.

[2]) O. Pettersson. Methode zur volumetrischen Bestimmung der im Wasser gelösten Gase: Berichte d. deutsch. chem. Ges. 22, S. 1434 (1898).

	N_2	O_2		N_2	O_2
	1898.			1903.	
1)	14,50 cm³/l	6,47 cm³/l	4)	18,67 cm³/l	9,36 cm³/l
	14,52 —	6,50 —		18,63 —	9,38 —
2)	17,03 —	7,05 —	5)	18,70 —	9,53 —
	17,06 —	7,08 —		18,68 —	9,31 —
	1899.		6)	17,87 —	8,74 —
3)	17,13 —	7,61 —		17,84 —	8,54 —
	17,17 —	7,62 —			

Die angeführten Analysen differieren mit einer Ausnahme nur um einige Hundertstel cm³. Dasselbe findet man bei der Durchsicht des ganzen vorhandenen Materials. Ausnahmsweise kommen bis 0,2 cm³ steigende Differenzen vor. Ein paar noch höhere dürften wohl von zufälligen Ursachen herrühren. Im ganzen würde ich die Unsicherheit der Sauerstoffzehrungszahl als zwischen 0,1 und 0,2 cm³/l liegend schätzen. 0,3 cm³/l übersteigende Fehler werden nur in ganz extremen Fällen vorkommen.

Es soll nun an der Hand des vorhandenen älteren Analysenmaterials gezeigt werden, welches veränderte Bild man eventuell von den Sauerstoffvariationen bekommt und wie dieses möglicherweise auf die hydrographische Charakterisierung einwirken könnte. Zu diesem Zwecke wurde aus den Stickstoff- und Sauerstoffbestimmungen der Terminfahrten der verschiedenen an der Internationalen Meeresforschung beteiligten Länder vor 1906 eine Auswahl getroffen, nämlich die wichtigsten hydrographischen Stationen der baltischen Gewässer sowie einige der Nordsee, des Nord-Atlantischen Ozeans und des Eismeeres[1]). Die Stationen wurden von den beteiligten Ländern stets ungefähr gleichzeitig besucht. Um eine eventuelle Einwirkung der Jahreszeit mit in Betracht zu ziehen, wurde das Material eines ganzen Jahres, nämlich 1903—04, genommen. Die Probeentnahme geschah damals bekanntlich vier Mal im Jahre, nämlich im November, Februar, Mai und August. Ausserdem sind zur Erörterung einiger spezieller Fragen einige Oberflächenwerte von anderen Jahren mit angeführt, sowie die einzigen mir zugänglichen Stickstoffbestimmungen von Ozeanwasser vom August 1903.

Die verschiedenen Kolonnen der Tabelle enthalten 1) Tiefe in Metern, 2) Temperatur, 3) Salzgehalt in ‰, 4) Chlorgehalt in ‰, 5) Stickstoffgehalt in cm³/l (0° 760 mm), 6) Sauerstoffgehalt in cm³/l, 7) den aus dem Stickstoffgehalte berechneten biologisch unbeeinflussten Sauerstoffgehalt

[1]) Conseil permanent international etc.: Bulletins des résultats: 1902 November, 1903 August, November, 1904 Februar, Mai, August. Finnländische hydrographisch-biologische Untersuchungen No. I. Helsingfors, 1907. S. 54—58 und 128—131.

O_2^N, 8) Sättigungsgehalt, d. h. der Sauerstoffgehalt, der zugegen wäre, wenn das Wasser bei angegebener Temperatur und angegebenem Salzgehalt an Sauerstoff bei 760 mm totalem Atmosphärendruck mit Sauerstoff gesättigt wäre, 9) das hundertfache Verhältnis des gefundenen und biologisch unbeeinflussten Sauerstoffgehaltes $100 \times O_2/O_2^N$, 10) das hundertfache Verhältnis des gefundenen Sauerstoffgehaltes und des Sättigungsgehaltes d. h. der alte Sättigungsprozentgehalt $100 \times O_2/O'_2$ und schliesslich 11) die Sauerstoffzehrung $O_2^N - O_2$ in cm^3/l. Bezüglich O_2 und des »alten« Sättigungsgrades $100\ O_2/O'_2$ ist noch zu bemerken, dass O'_2 nicht den Tabellen von J. P. Jacobsen[1]) entnommen werden darf, dessen Sauerstoffsättigungsgehalte nach der Methode von Winkler-Bjerrum bestimmt sind, sondern den volumenometrisch bestimmten Werten von Chas. J. J. Fox, in denen auch der Stickstoff volumenometrisch bestimmt ist. Bekanntlich besteht eine kleine systematische Differenz zwischen diesen beiden Methoden, indem man nach Winkler etwas niedrigere Werte erhält. Will man titrimetrisch bestimmte Sauerstoffzahlen mit volumenometrischen vergleichen, so ist eine entsprechende Korrektur anzubringen.

Eine Betrachtung der Tabellen ergibt, dass die Sauerstoffzehrungen $O_2^N - O_2$ nach der neuen Art angegeben, meist höhere Werte annehmen, als die alten Sättigungszahlen ergeben und zwar in allen den Fällen, in denen das Wasser an Stickstoff und damit auch an biologisch unbeeinflusstem Sauerstoff O_2^N übersättigt ist. Und letzteres ist fast durchweg der Fall, besonders im Ostseebecken, und zwar in allen Tiefen und zu allen Jahreszeiten, ausser an einigen Oberflächenpunkten im Spätherbst, m. a. W. O_2/O_2^N ist meist $< O_2/O'_2$ weil $O_2^N > O'_2$. Letztes ist wiederum höchst wahrscheinlich eine Folge des beständigen Mischungsprozesses, ein Ausdruck der bekannten Tatsache, die auch aus den angeführten Mischungsbeispielen hervorgeht, dass an Luft gesättigtes Meerwasser von verschiedenen Temperaturen nach Mischung stets übersättigt ist. Dass es die Mischungsverhältnisse sind, die dieses bedingen, geht am deutlichsten aus den Gehaltszahlen für die Oberfläche im November hervor. Betrachten wir hier die alten Sättigungsprozente $100 \times O_2/O'_2$, so finden wir, wie immer zu dieser Jahreszeit, ausgeprägte Untersättigung, die bisher immer dem Umstand zugeschrieben wurde, dass das Wasser bei höherer Temperatur früher gesättigt gewesen war, und also der Sättigungsprozent abnehmen musste, wenn die Temperatur sank und folglich die Löslichkeit und damit O'_2 zunahm. Nun zeigt aber

[1]) J. P. Jacobsen. Die Löslichkeit von Sauerstoff im Meerwasser durch Winklers Titriermethode bestimmt. Meddelelser fra Kommissionen for Havundersögelser, Serie Hydrografi, Bind I, No. 8, 1905.

Tabelle 2.

1 Tiefe m	2 t°	3 S‰	4 Cl‰	5 N_2 cm³/l	6 O_2 cm³/l	7 O_2^N cm³/l	8 O_2' cm³/l	9 $100\frac{O_2}{O_2^N}$	10 $100\frac{O_2}{O_2'}$	11 $O_2^N - O_2$ cm³/l	12 Bemerkungen
					Bottnischer Meerbusen.						
					F 8. 64°40′ N 22°42′ E, 1903 X 30.						
0	4.07	3.22	1.77	17.29	8.24	9.45	9.07	87	91	1.2	
50	3.48	3.87	2.13	17.50	7.88	9.59	9.17	82	86	1.7	
76	2.23	4.09	2.25	18.01	7.47	9.94	9.28	75	81	2.5	
					F 24. 62°51′ N 18°55′ E, 1903 XI 2.						
0	5.15	5.19	2.86	16.73	8.04	9.12	8.72	88	92	1.1	
195	2.33	6.17	3.40	17.72	6.51	9.78	9.31	67	70	3.3	
					Finnischer Meerbusen.						
					F 54. 59°43′ N 25°01′ E, 1903 XI 13.						
0	7.17	5.34	2.94	15.53	7.00	8.36	8.30	84	84	1.4	
106	4.22	8.21	4.53	16.58	2.83	9.06	8.75	31	31	6.2	
					Nördliche Ostsee.						
					F 64. 60°12.5′ N 19°07′ E, 1903 XI 4.						
0	6.44	5.07	2.79	16.27	7.34	8.83	8.45	83	87	1.5	
100	5.50	6.53	3.60	16.70	6.75	9.12	8.57	74	79	2.4	
200	4.12	6.71	3.70	17.62	7.13	9.72	8.85	73	81	2.6	
262	4.01	6.76	3.73	17.05	6.88	9.37	8.87	73.5	78	2.5	
					F 74. 59°01′ N 21°05′ E, 1903 X 28.						
0	6.96	6.85	3.78	15.28	7.39	8.21	8.27	90	89	0.8	
60	7.22	6.94	3.83	15.33	7.31	8.25	8.21	89	89	0.9	
100	4.71	8.62	4.76	16.31	4.49	8.89	8.62	50.5	52	4.4	
141	4.31	10.01	5.53	16.26	2.50	8.88	8.63	28	29	6.4	
					Südliche Ostsee.						
					Bornholmtiefe. 55°30′ N 15°43′ E, 1903 XI 5.						
10	9.13	7.39	4.08	15.66	7.18	8.46	7.82	85	92	1.3	
60	5.94	10.55	5.83	16.41	5.57	8.99	8.27	62	67	3.4	
88	3.34	17.14	9.48	16.45	3.65	9.10	8.43	40	43	5.45	
					D Ostsee 12. 54°54′ N 19°15′ E, 1903 XI 19.						
75	4.13	9.60	5.30	15.93	4.815	8.68	8.69	56	55	3.9	
104	3.97	11.96	6.61	16.005	2.825	8.73	8.60	32	33	5.9	

1 Tiefe m	2 t°	3 S ‰	4 Cl ‰	5 N_2 cm³/l	6 O_2 cm³/l	7 O_2^N cm³/l	8 O'_2 cm³/l	9 $100\frac{O_2}{O_2^N}$	10 $100\frac{O_2}{O'_2}$	11 $O_2^N - O_2$ cm³/l	12 Bemerkungen
					Skagerrak.						
					S Skag. 7. 58°26′ N 9°44′ E, 1903 XI 13.						
5	9.62	30.82	17.06	13.00	6.45	7.00	6.65	92	97	0.55	$100\frac{O_2^N}{O'_2}$ = 10
50	8.97	34.78	19.25	12.95	5.37	7.00	6.56	77	82	1.6	» = 10
100	6.94	35.07	19.41	13.53	5.46	7.41	6.82	74	80	1.95	» = 10
300	6.26	35.14	19.45	13.62	5.72	7.47	6.93	76	83	1.75	» = 10
600	5.49	35.08	19.42	13.92	5.39	7.67	7.04	70	77	2.3	» = 10
					Nordsee.						
					D Nordsee 8. 58°19′ N 5°43′ E, 1903 XI 7.						
30	10.89	33.51	18.55	11.68	5.71	6.16	6.36	93	90	0.45	[1]) N'_2 = 12.8
75	10.68	34.34	19.01	11.885	5.575	6.30	6.35	88.5	88	0.7	$100\frac{N_2}{O'_2}$ = 99
200	6.85	35.12	19.44	12.61	5.82	6.79	6.84	86	85	1.0	
317	6.12	35.13	19.45	12.785[1])	5.67	6.90	6.95	82	82	1.2	$100\frac{O_2^N}{O'_2}$ = 99
					H 5. 54°05′ N 1°28′ E, 1903 XI 3.						
50	10.0	34.49	19.09	12.04	5.78	6.40	6.42	90	90	0.6	
50	10.0	34.49	19.09	11.92	5.83	6.33	6.42	92	91	0.5	
					Finnischer Meerbusen.						
					F 54. 59°43.2′ N 25°01′ E, 1904 I 31.						
0	1.35	5.54	3.05	17.87	9.31	9.87	9.58	94	97	0.6	
60	4.12	6.04	3.33	16.72	7.24	9.13	8.90	79	81	1.9	
91	4.76	6.31	3.48	16.40	6.13	8.95	8.74	68	70	2.8	
					F 52 A. 59°59′ N 24°57′ E, 1904 III 9.						
0	−0.18	5.10	2.81	18.49	8.90	10.27	10.02	87	89	1.3	
37.5	±0.00	5.55	3.06	18.27	8.81	10.13	9.93	87	89	1.4	
					Nördliche Ostsee.						
					F 64. 60°12.5′ N 19°07′ E, 1904 II 9.						
0	1.16	5.64	3.11	17.99	8.76	9.95	9.62	88	91	1.2	
50	3.34	5.93	3.27	16.90	8.51	9.25	9.08	92	94	0.8	
200	4.75	6.49	3.58	16.46	7.35	8.97	8.74	82	84	1.6	
275	4.85	6.56	3.62	16.48	7.14	8.97	8.70	80	82	1.8	

1 Tiefe m	2 t°	3 S ‰	4 Cl ‰	5 N_2 cm³/l	6 O_2 cm³/l	7 O_2^N cm³/l	8 O'_2 cm³/l	9 $100\frac{O_2}{O_2^N}$	10 $100\frac{O_2}{O'_2}$	11 $O_2^N - O_2$ cm³/l	12 Bemerkungen
					Südliche Ostsee.						
					D Ostsee 12. 54°54′ N 19°15′ E, 1904 II 17.						
60	2.43	7.49	4.14	16.66	8.28	9.10	9.20	91	90	0.8	
90	4.29	10.30	5.69	15.95	3.22	8.68	8.62	37	37	5.5	
105	4.00	11.82	6.53	16.14	1.60	8.82	8.59	18	19	7.2	
					Skagerrak.						
					S Skag. 7. 58°26′ N 9°44′ E, 1904 II 17.						
20	4.54	33.39	18.48	13.89	6.91	7.64	7.30	90.5	95	0.7	
50	6.24	34.63	19.17	13.55	6.40	7.42	6.94	86	92	1.0	
100	7.24	35.12	19.44	13.63	5.78	7.48	6.78	77	85	1.7	
300	6.51	35.17	19.47	13.25	5.68	7.22	6.88	79	83	1.5	
650	5.77	35.16	19.46	13.25	5.17	7.22	7.00	72	74	2.0	
					Bottnischer Meerbusen.						
					F 8. 64°40′ N 22°42′ E, 1904 V 21.						
50	0.47	3.53	1.94	19.48	9.45	10.87	9.94	87	95	1.5	
95	0.86	3.84	2.11	19.53	8.94	10.92	9.82	82	91	2.0	
					F 24. 62°47′ N 19°01′ E, 1904 V 19						
0	0.37	5.30	2.92	18.92	9.55	10.54	9.86	90.5	97	1.0	
50	0.15	5.50	3.03	19.10	9.31	10.66	9.89	87	94	1.35	
100	1.24	5.70	3.14	18.40	8.32	10.21	9.59	81	87	1.9	
175	2.84	6.00	3.31	18.40	7.35	10.22	9.18	72	80	2.9	
					Finnischer Meerbusen.						
					F 54. 59°43′ N 25°01′ E, 1904 V 14.						
0	2.99	5.30	2.92	18.33	9.08	10.15	9.20	89	99	1.1	
50	1.21	6.62	3.65	18.37	8.58	10.20	9.55	84	90	1.6	
103	3.99	8.62	4.76	16.97	3.54	9.31	8.78	38	40	5.8	
					Nördliche Ostsee.						
					F 64. 60°12.5′ N 19°07′ E, 1904 V 17.						
0	3.16	5.81	3.20	18.02	8.87	9.96	9.13	89	97	1.1	
50	1.69	6.08	3.35	18.63	8.92	10.38	9.47	86	94	1.5	
100	1.48	6.22	3.43	18.27	8.71	10.14	9.51	86	92	1.4	
200	2.68	6.38	3.52	17.67	7.88	9.75	9.20	81	86	1.9	
275	2.73	6.44	3.55	17.67	7.48	9.75	9.19	77	81	2.3	

1 Tiefe m	2 t°	3 S ‰	4 Cl ‰	5 N_2 cm³/l	6 O_2 cm³/l	7 O_2^N cm³/l	8 O'_2 cm³/l	9 $100\frac{O_2}{O_2^N}$	10 $100\frac{O_2}{O'_2}$	11 $O_2^N - O_2$ cm³/l	12 Bemerkungen
				F 74. 59°01′ N 21°05′ E, 1904 V 23.							
0	3.78	6.49	3.58	17.83	8.98	9.85	8.95	91	100	0.9	
50	1.99	6.94	3.83	17.77	8.83	9.83	9.34	90	95	1.1	
100	4.08	9.65	5.33	16.84	2.94	9.27	8.70	32	34	6.3	
150	4.30	10.39	5.74	16.79	2.54	9.23	8.61	28	29	6.7	
				Südliche Ostsee.							
				Bornholmtiefe. 55°30′ N 15°43′ E, 1904 V 6.							
10	4.08	7.20	3.97	17.71	8.59	9.79	8.84	88	97	1.2	
20	3.81	7.20	3.97	17.69	8.76	9.78	8.90	90	98	1.0	
40	3.79	7.21	3.98	17.94	8.93	9.94	8.90	90	100	1.0	
50	2.36	7.95	4.39	17.94	8.24	9.95	9.18	83	90	1.7	
60	2.68	12.43	6.87	17.03	6.90	9.41	8.86	73	78	2.5	
75	3.76	15.95	8.82	16.62	2.48	9.19	8.42	27	29	6.7	
				D Ostsee 12. 54°57′ N 18°54′ E, 1904 V 13.							
5	5.19	7.29	4.02	16.435	8.78	8.96	8.59	98	102	0.2	$O_{N_2} - O'_2$
75	4.04	9.60	5.30	15.99	5.15	8.71	8.71	59	59	3.6	$= -0.07$
85	4.26	10.59	5.85	15.71	4.59	8.54	8.61	54	53	4.0	$= -0.03$
95	4.30	11.17	6.17	15.72	4.25	8.55	8.57	50	50	4.3	
105	4.28	11.56	6.39	15.915	2.22	8.68	8.55	26	26	6.45	
				D Ostsee 2. 54°56′ N 10°13′ E, 1904 V 10.							
20	5.57	22.09	12.22	14.60	6.79	7.95	7.72	85	88	1.1	
				Skagerrak.							
				S Skag 7. 58°26′ N 9°44′ E, 1904 V 17.							
20	4.89	34.16	18.91	13.98	6.17	7.71	7.20	80	86	1.5	
50	5.53	34.63	19.17	13.91	6.26	7.66	7.06	82	89	1.4	
75	5.89	34.81	19.27	14.09	6.09	7.79	6.99	78	87	1.7	
100	5.87	34.87	19.30	13.62	5.69	7.47	6.99	76	81	1.8	
200	6.15	35.01	19.38	13.56	5.86	7.43	6.95	79	84	1.6	
300	5.39	—	—	14.07	6.32	7.77	7.06	81	89	1.45	
400	5.69	35.08	19.42	13.79	5.90	7.59	7.01	78	84	1.7	
500	5.43	35.08	19 .42	13.93	5.93	7.68	7.05	77	84	1.75	
				Nordsee.							
				H 5. 54°05′ N 1°28′ E, 1904 V 3.							
0	6.9	34.61	19.16	13.30	6.58	7.25	6.85	91	96	0.7	
55	6.9	34.63	19.17	13.28	6.56	7.23	6.85	85	96	0.7	

1 Tiefe m	2 t°	3 S ‰	4 Cl ‰	5 N_2 cm³/l	6 O_2 cm³/l	7 O_2^N cm³/l	8 O_2 cm³/l	9 $100\frac{O_2}{O_2^N}$	10 $100\frac{O_2}{O_2'}$	11 $O_2^N - O_2'$ cm³/l	12 Bemerkungen
Eismeer.											
R 4. 71°31′ N 33°30′ E, 1904 V 10.											
100	3.65	34.47	19.08	14.01	7.12	7.73	7.39	92	96	0.6	
250	3.0	34.70	19.21	13.71	6.51	7.53	7.49	86	87	1.0	
Bottnischer Meerbusen.											
F 8. 64°40′ N 22°42′ E, 1904 VIII 10.											
0	10.85	3.42	1.88	16.10	7.56	8.71	7.72	87	98	1.1	
50	5.46	3.64	2.00	18.09	7.63	9.97	8.73	77	87	2.3	
98	2.42	3.93	2.16	18.24	8.09	10.07	9.41	80.5	86	2.0	
F 24. 62°51′ N 18°55′ E, 1904 VIII 14.											
0	10.38	5.10	2.81	15.43	7.35	8.30	7.73	89	95	0.95	
50	2.35	5.57	3.07	18.32	8.56	10.15	9.33	84	92	1.6	
100	2.54	5.86	3.23	18.24	7.47	10.11	9.28	74	80.5	2.6	
199	2.82	6.00	3.31	18.07	6.53	10.01	9.19	65	71	3.5	
F 25 B. 63°01′ N 18°23′ E, 1904 VIII 13.											
50	1.47	5.66	3.12	19.04	8.18	10.62	9.54	77	86	2.4	
97	1.84	5.77	3.18	18.63	7.00	10.36	9.44	67.5	74	3.4	
100	1.83	5.77	3.18	19.43	7.72	10.90	9.44	71	82	3.2	
Finnischer Meerbusen.											
F 54. 54°43′ N 25°01′ E, 1904 VIII 23.											
0	13.61	5.19	2.86	14.14	6.88	7.70	7.21	89	95.5	0.8	
50	2.23	6.78	3.74	17.73	7.15	9.79	9.29	73	77	2.6	
105	3.83	8.69	4.80	17.27	2.72	9.52	8.80	29	31	6.8	
Nördliche Ostsee.											
F 64. 60°12.5′ N 19°07′ E, 1904 VIII 18.											
0	11.98	5.26	2.90	15.06	7.20	8.07	7.46	88	97	0.9	
50	3.47	6.29	3.47	17.94	8.17	9.93	9.02	82	91	1.8	
100	4.08	6.56	3.62	17.97	7.74	9.94	8.88	78	87	2.2	
200	4.09	6.74	3.72	17.70	7.22	9.78	8.86	74	81	2.6	
296	4.04	6.78	3.74	17.91	7.38	9.92	8.87	74	83	2.5	

1 Tiefe m	2 t°	3 S‰	4 Cl‰	5 N_2 cm³/l	6 O_2 cm³/l	7 O_2^N cm³/l	8 O'_2 cm³/l	9 $100\frac{O_2}{O_2^N}$	10 $100\frac{O_2}{O'_2}$	11 $O_2^N - O_2$ cm³/l	12 Bemerkungen
					F 75. 58°54′ N 20°07′ E, 1904 VIII 19.						
0	14.72	5.77	3.18	14.46	6.95	7.71	7.02	90	99	0.8	
50	2.57	6.89	3.80	18.26	7.53	10.14	9.21	74	82	2.6	
100	4.26	9.74	5.38	17.20	2.77	9.50	8.66	29	32	6.7	
150	4.56	10.50	5.80	17.36	2.59	9.61	8.55	27	30	7.0	
173	4.57	9.69	5.35	16.99	2.63	9.36	8.59	28	31	6.7	
					Südliche Ostsee.						
					D Ostsee 12. 54°54′ N 18°15′ E, 1904 VIII 18.						
5	15.49	7.21	3.98	12.81	6.36	6.72	6.86	95	93	0.4	
85	3.40	9.06	5.00	16.31	4.67	8.90	8.87	52	53	4.2	
103	3.82	11.38	6.29	16.00	1.67	8.73	8.66	19	19	7.1	
					Skagerrak.						
					S Skag 7. 58°26′ N 9°44′ E, 1904 VIII 8.						
5	16.96	31.58	17.48	11.56	5.34	6.06	5.76	88	93	0.7	
40	6.55	34.85	19.29	13.76	6.40	7.56	6.89	85	93	1.2	
500	5.31	35.10	19.43	14.04	5.28	7.76	7.07	68	75	2.5	
700	5.17	35.10	19.43	13.86	5.36	7.63	7.10	70	75.5	2.3	
					Nordsee.						
					D Nordsee 8. 58°23′ N 5°50′ E, 1904 VIII 6.						
150	5.75	35.03	19.39	12.97	6.05	7.02	7.00	86	86	1.0	
					Eismeer.						
					R 4. 70°41′ N 46°00′ E, 1904 VIII 2.						
0	7.8	34.45	19.07	12.89	5.95	6.97	6.72	85	89	1.0	
50	1.5	34.67	19.19	14.27	6.33	7.90	7.76	80	82	1.6	
100	0.25	34.67	19.19	15.58	5.09	8.81	8.01	58	64	3.7	
					Finnischer Meerbusen.						
					F 53. 59°51.5′ N 24°53′ E, 1900 V 26.						
0	6.26	5.41	2.98	17.36	9.59	9.53	8.47	100.6	113	—0.06	
					F 53. 59°51.5′ N 24°53′ E, 1901 V 28.						
0	6.34	4.89	2.69	15.99	8.49	8.65	8.48	98	100	0.16	

1 Tiefe m	2 t°	3 S ‰	4 Cl ‰	5 N_2 cm³/l	6 O_2 cm³/l	7 O_2^N cm³/l	8 O'_2 cm³/l	9 $100\frac{O_2}{O_2^N}$	10 $100\frac{O_2}{O'_2}$	11 $O_2^N - O'_2$ cm³/l	12 Bemerkungen
					Atlantischer Ozean.						
					Da Atl 4 C. 64°43′ N 6°20′ W, 1903 VIII 23.						
100	2.35	34.90	19.32	14.14[1]	6.26	7.93	7.60	80	82	1.6	[1]) $N'_2 = 13.81$
700	−0.95	35.01	19.38	15.06[2]	7.18	8.46	8.26	85	87	1.3	$100\frac{N_2}{N'_2} = 102$
											$100\frac{O_2^N}{O'_2} = 103$
					Da Atl 7. 62°12′ N 9°56′ W, 1903 VIII 13.						[2]) $N'_2 = 14.73$
665	4.90	35.14	19.45	13.63	5.94	7.48	7.14	79	83	1.5	$100\frac{N_2}{N'_2} = 102$
											$100\frac{O_2^N}{O'_2} = 102$
					Da Atl 10 A. 64°57′ N 8°32′ W, 1903 VIII 7.						
10	7.13	34.76	19.24	12.79	6.63	6.90	6.81	96	97	0.3	$100\frac{O_2^N}{O'_2} = 101$
1000	−0.72	34.88	19.31	15.76	7.17	8.94	8.21	80	87	1.8	» = 109
2000	−1.04	34.89	19.32	14.96	7.09	8.38	8.26	84.5	86	1.3	» = 102

der Vergleich der O_2^N-Zahlen mit den O_2-Zahlen, dass diese physikalisch bedingte Herbstuntersättigung in den hier untersuchten Fällen entweder überhaupt nicht oder in nur sehr unbedeutendem Masse hervor tritt. Um diese Verhältnisse näher zu verfolgen und deutlicher zum Ausdruck zu bringen, wurde noch eine Tabelle 3 mit nur Oberflächenwerten zusammengestellt. Sie enthält ausser den in der vorigen Tabelle 2 angegebenen N_2- und O_2-Grössen auch den Sättigungsgehalt N'_2 an Stickstoff (entsprechend O'_2) und den Sättigungsprozent $100 \times N_2/N'_2$ sowie auch den Sättigungsprozent des biologisch unbeeinflussten Sauerstoffs $100 \times O_2^N/O'_2$.

Wir finden in dieser Tabelle in den Baltischen Gewässern für November allgemein an Sauerstoff untersättigtes Wasser ($100 \times O_2/O'_2 < 100$) gleichzeitig aber an Stickstoff und biologisch unbeeinflussten Sauerstoff übersättigtes oder ganz nahe gesättigtes (nicht weniger als 98 %)[1]) Wasser ($100 \times N_2/N'_2$ bzw. $100 \times O_2^N/O'_2 > 100$). Gleichzeitig sind die $O_2^N - O_2$-Werte positiv. Dieses deuten wir folgendermassen: Die Sauerstoffuntersättigung ist keine physikalische Herbstuntersättigung,

[1]) Eine Ausnahme bildet F 64. 1898 XII 11, mit 92 %. Offenbar ist hier der N_2-Wert 15,08 zu niedrig. Denn aus ihm berechnet sich eine negative Zehrung $O_2^N - O_2$, also eine biologische Sauerstoffproduktion, die zu dieser Jahreszeit wenig wahrscheinlich ist.

Tabelle 3.

Dat.	Station	Position Lat. N.	Long. E.	Tiefe m.	t°	Cl ‰	
Oktober—November.							Bott
1903 X 30	F 8	64°40′	22°42′	0	4.07	1.77	
— XI 2	F 24	62°51′	18°55′	0	5.15	2.86	
							Fin
1903 XI 13	F 54	59°43′	25°01′	0	7.17	2.94	
							Nö
1898 XII 11	F 64	60°12.5′	19°07′	0	4.47	3.33	
1899 X 9	F 64	60°12.5′	19°07′	0	8.82	3.06	
1903 XI 4	F 64	60°12.5′	19°07′	0	6.44	2.79	
— X 28	F 74	59°01′	21°05′	0	6.96	3.78	
							S
1903 XI 5	Bornholmtiefe	55°30′	15°43′	10	9.13	4.08	
1902 XI 3	D Ostsee 11	55°11′	16°40′	0	8.4	4.01	
— X 31	— 7	55°06′	13°15′	0	9.40	4.32	
— X 31	— 6	55°16′	13°13′	0	9.33	4.35	
— X 30	— 5	54°28′	12°15′	0	9.00	6.30	
— X 30	— 4	54°10′	11°16′	0	8.7	9.08	
							S
1903 XI 13	S Skag 7	58°26′	9°44′	5	9.62	17.06	
1902 XI 17	D Nordsee 12	57°00′	8°03′	5	8.25	17.98	
— XI 16	— 10	57°31.5′	7°36.5′	5	7.75	17.01	
— XI 11	— 2	55°21′	4°08′	0	10.45	19.35	
— XI 10-11	— 1	54°41′	6°12′	0	11.35	19.14	
Januar—März.							Fin
1904 I 31	F 54	59°43.2′	25°01′	0	1.35	3.05	
— III 9	F 52 A	59°59′	24°57′	0	—0.18	2.81	
							Nö
1904 II 9	F 64	60°12.5′	19°07′	0	1.16	3.11	
							S
— II 17	S Skag 7	58°26′	9°44′	20	4.54	18.48	

Tabelle 3.

$100\frac{N_2}{N'_2}$	O_2 cm³/l	O_2^N cm³/l	O'_2	$100\frac{O_2}{O_2^N}$	$100\frac{O_2}{O'_2}$	$100\frac{O_2^N}{O'_2}$	$O_2^N - O_2$ cm³/l
...sen.							
104	8.24	9.45	9.07	87	91	104	1.2
104	8.04	9.12	8.72	88	92	104	1.1
...sen.							
101	7.00	8.36	8.30	84	84	101	1.4
93	8.48	8.09	8.82	105	96	92	—0.4(?)
101	7.10	8.07	7.98	88	89	101	1.0
104	7.84	8.83	8.45	83	87	105	1.5
99	7.39	8.21	8.27	90	89	99	0.8
107	7.18	8.46	7.82	85	92	108	1.3
98	7.53	7.80	7.96	97	95	98	0.3
99	7.09	7.68	7.76	92	91	99	0.6
99	7.31	7.66	7.78	96	94	98.5	0.35
99	7.26	7.57	7.66	96	95	99	0.3
101	7.27	7.57	7.47	96	97	101.5	0.3
104	6.45	7.00	6.65	92	97	105	0.55
98	6.26	6.64	6.77	94	93	98	0.4
99	6.59	6.90	6.91	95	95	100	0.3
99	5.53	6.29	6.35	88	87	99	0.8
99	4.44	6.16	6.25	72	71	99	1.7
...usen.							
102	9.31	9.87	9.58	94	97	103	0.6
102	8.90	10.27	10.02	87	89	103	1.3
103	8.76	9.95	9.62	88	91	103	1.2
104	6.91	7.64	7.30	90.5	95	105	0.7

Dat.	Station	Position Lat. N.	Long. E.	Tiefe m.	t°	Cl ‰
Mai.						Bo
1904 V 19	F 24	62°47′	19°01′	0	0.37	2.92
						F
1900 V 26	F 53	59°51.5′	24°53′	0	6.26	2.98
1904 V 14	F 54	59°43′	25°01′	0	2.99	2.92
						N
1904 V 17	F 64	60°12.5′	19°07′	0	3.16	3.20
— V 23	F 74	59°01′	21°05′	0	3.78	3.58
1904 V 6	Bornholmt.	55°30′	15°43′	10	4.08	3.97
— V 13	D Ostsee 12	54°57′	18°54′	5	5.19	4.02
						Skag
1904 V 17	S Skag 7	58°26′	9°44′	20	4.89	18.91
— V 3	H 5	54°05′	1°28′	0	6.9	19.16
August.						Bo
1904 VIII 10	F 8	64°40′	22°42′	0	10.85	1.88
— VIII 14	F 24	62°51′	18°55′	0	10.38	2.81
						F
1904 VIII 23	F 54	54°43′	25°01′	0	13.61	2.86
1904 VIII 18	F 64	60°12.5′	69°07′	0	11.98	2.90
— VIII 19	F 75	58°54′	20°07′	0	14.72	3.18
						Skag
1902 VIII 20	S Skag 7	58°25′	9°50′	20	6.93	19.26
1905 VIII 4	S Skag 7	58°26′	9°44′	10	7.92	18.95
1903 VIII 12	H 6	53°44′	0°32′	0	12.5	18.93
						At
1903 VIII 7	Da Atl 10 A	64°57′	8°32′W	10	7.13	19.24

	$100\,\frac{N_2}{N'_2}$	O_2 cm³/l	O_2^N cm³/l	O'_2	$100\,\frac{O_2}{O_2^N}$	$100\,\frac{O_2}{O'_2}$	$100\,\frac{O_2^N}{O'_2}$	$O_2^N - O_2$ cm³/l
ısen.								
	106	9.55	10.54	9.86	90.5	97	107	1.0
ısen.								
	111	9.59	9.53	8.47	100.6	113	112.5	—0.06
	109	9.08	10.15	9.20	89	99	110	1.1
	108	8.87	9.96	9.13	89	97	109	1.1
	109	8.98	9.85	8.95	91	100	110	0.9
	109	8.59	9.79	8.84	88	97	111	1.2
	103	8.78	8.96	8.59	98	102	104	0.2
ee.								
	106	6.17	7.71	7.20	80	86	107	1.5
	105	6.58	7.25	6.85	91	96	106	0.7
usen.								
	111	7.56	8.71	7.72	87	98	113	1.1
	107	7.35	8.30	7.73	89	95	108	0.95
usen.								
	106	6.88	7.70	7.21	89	95.5	107	0.8
e.								
	107	7.20	8.07	7.46	88	97	108	0.9
	109	6.95	7.71	7.02	90	99	110	0.8
ee.								
	107	7.26	7.44	6.84	97.5	106	109	0.18
	107	7.25	7.30	6.73	99	108	108	0.05
	107	6.4	6.65	6.14	96	104	108	0.2(5)
	101	6.63	6.90	6.81	96	97	101	0.3

denn sonst müsste auch der Stickstoff untersättigt sein, sondern sie ist der biologischen Sauerstoffzehrung zuzuschreiben, wie die $O_2^N - O_2$-Werte ergeben. Die besonders in den nördlichen Teilen des Ostseebeckens auftretende N_2- und O_2-Übersättigung ist wahrscheinlich dem erwähnten Mischungseinfluss zuzuschreiben. Wir haben also, was bisher nicht möglich war, auch im Oberflächenwasser einen Sauerstoffschwund feststellen können.

Es mag noch auf die Übereinstimmung der Werte von $100 \times N_2/N'_2$ und $100 \times O_2^N/O'_2$ hingewiesen werden, die natürlich ist, weil O_2^N aus N_2 abgeleitet ist. Eine absolute Übereinstimmung kann man nicht erwarten, weil man zur Berechnung von O_2^N den vom Sättigungsgehalte abweichenden N_2-Gehalt mit einem nur für genaue Sättigung gültigen Quotienten multipliziert, oder weil m. a. W. N_2/O_2^N und N'_2/O'_2 nicht genau gleich sein können. Jedenfalls ist aber die Geringigkeit der Abweichung ein weiterer Beweis und eine gute Kontrolle der Verwendbarkeit der O_2^N-Zahl.

Für die Beurteilung der Verhältnisse im Winter ist das Zahlenmaterial für 1904 knapp. Die Zahlen für den Finnischen Meerbusen und die nördliche Ostsee zeigen, dass hier die von der Mischung herrührende Übersättigung ($100 \times N_2/N'_2$ und $100 \times O_2^N/O'_2 > 100$) fortbesteht. In der südlichen Ostsee und in der Nordsee ist das Wasser gemäss hier nicht mitgeteilter Zahlen für den Winter 1903 meist ziemlich genau gesättigt[1]). Überall ist aber $O_2^N - O_2$ positiv, also ein Sauerstoffschwund zu verzeichnen.

Von besonderem Interesse sind die Verhältnisse im Mai nach Anfang der Sommererwärmung. Hier verändern die Temperatursteigerung und Mischung den Sättigungszustand in gleichem Sinne und lassen somit eine stärkere Übersättigung erwarten, als die Temperatursteigerung allein. Das vorhandene Material bestätigt dieses auch, indem wir nämlich durchwegs für $100 \times N_2/N'_2$ und $100 \times O_2^N/O'_2$-Werte bedeutend über 100 (bis 113) erhalten, dieses auch in den Fällen, wo der Prozentgehalt des tatsächlichen Sauerstoffs $100 \times O_2/O'_2$ Untersättigung aufweist. Die $100 \times O_2/O_2^N$-Werte sind fast durchwegs kleiner als hundert und die $O_2^N - O_2$-Werte positiv, was also auf eine resultierende Sauerstoffzehrung auch für diese Jahreszeit hindeutet.

Ausgeprägter als anderswo sind die Verhältnisse im Finnischen Meerbusen. Hier haben die Analysenresultate der jährlichen Terminfahrten

[1]) Geringere Abweichungen vom Sättigungszustand können auch dadurch zustande kommen, dass der Sättigungsprozentgehalt auf eine Atmosphäre von 760 mm bezogen wird. Bei ausführlicher Verwendung der neuen Betrachtungsweise ist natürlich auch der herrschende Luftdruck zu beachten.

für diese Jahreszeit besonders im inneren Teile des Meeresgebietes stets eine extrem hohe Sauerstoffübersättigung gezeigt, mit $100 \times O_2/O'_2$ zwischen 110 bis ca. 120 liegend. Leider gibt es für diese inneren Gebiete kein Stickstoffmaterial. Ich habe die hier herrschenden hydrographischen Verhältnisse früher im Zusammenhang mit Alkalinitäts-, Kohlensäure-, p_H-Bestimmungen und Berechnungen des CO_2-Druckes behandelt[1]), und fand dort in ausgeprägter regionaler Verteilung stark alkalisches Wasser, hohe Alkalinität, und im Vergleich hiermit niedrigen Gehalt an totaler Kohlensäure, alles Umstände, die der Zufuhr von karbonatreichem Süsswasser von den Zuflüssen an der Südküste des Meerbusens zugeschrieben wurden. Besonders deutlich liess sich dies aus der Oberflächenkarte erkennen, indem sich diese Verhältnisse gerade am ausgeprägtesten um die genannten Zuflussgebiete gruppierten und andere Gegenden sowohl auswärts wie einwärts hiervon nicht betroffen wurden. Diese Verhältnisse haben sich Jahr für Jahr an denselben Stellen wiederholt. Es liegt nahe, und ist auch von einigen Forschern ausgesprochen worden, dass diese Verhältnisse biologischen Umständen, nämlich der Assimilationstätigkeit der aufblühenden Phytoplanktonflora zuzuschreiben sind. Rein qualitativ gesehen, deutet eine starke Sauerstoffübersättigung bei gleichzeitigem Kohlensäuredefizit und damit alkalischer Reaktion darauf hin. Trotzdem ist die Erscheinung nur zum geringeren Teil eine biologische. Nur ein geringer Teil des Sauerstoffüberschusses kann in Beziehung gestellt werden zum Kohlensäuredefizit und der alkalischen Reaktion. Die ausgeprägte regionale Verteilung des alkalischen Wassers lässt den Einfluss des kalkhaltigen Süsswassers so deutlich erkennen, dass ein Zweifel über diesen nicht herrschen kann. Ohne diesen Einfluss wäre es unerklärlich, warum gewisse Punkte im innersten Teile des erwähnten Meeresgebietes die erwähnte Erscheinung garnicht, oder viel weniger ausgeprägt aufweisen. Was aber durch die Annahme der Süsswasserbeeinflussung unerklärt blieb, war die Sauerstoffübersättigung, und diese können wir nunmehr zum grössten Teil der erwähnten doppelten Einwirkung der Temperaturerhöhung und Mischung zuschreiben. Ein eventuelles Überwiegen der Assimilationstätigkeit des Phytoplanktons über die Atmungstätigkeit des Tierplanktons und hierdurch resultierende Sauerstoffübersättigung ist hiermit keineswegs ausgeschlossen, kann aber nicht aus den angeführten Daten als nachgewiesen betrachtet werden. Hierzu sind Bestimmungen des Stickstoffs nötig und zum Beleg auch Planktonuntersuchungen. Im

[1]) Kurt Buch. Ueber die Alkalinität, Wasserstoffionenkonzentration, Kohlensäure und Kohlensäuretension im Wasser der Finnland umgebenden Meere, Helsingfors 1917. S. 101—103, 108, 113—114. Vgl. auch die Oberflächenkarte.

älteren Material (mit Stickstoffanalysen) wurde für die inneren Teile des Ostseebeckens zu dieser Jahreszeit nur an einigen Punkten tatsächliche Sauerstoffübersättigung gefunden. Aber an diesen und auch den übrigen Punkten war die Stickstoffübersättigung doch stets grösser, was also gleichbedeutend mit überwiegender Respiration ist. Ein Überwiegen der Assimilation, das durch negative $O_2^N - O_2$-Werte zum Ausdruck kommt, fand ich im ganzen Material nur an zwei Stellen. Die erste war F 53 1900 V 26, mit dem innerhalb der Versuchsfehler liegenden Betrage von 0,06 cm³. Da die Sauerstoffsättigung hier 113 % betrug, so ist es ja nicht unwahrscheinlich, dass eine bisweilen gefundene noch höhere Sättigung bis 120 % in der Tat zum Teil der Assimilation zugeschrieben werden kann[1]).

Betrachten wir nun die Verhältnisse im Sommer, so gestalten sie sich nur wenig anders als im Frühjahr. Die Übersättigung in der Oberfläche nimmt ab, bleibt aber doch stellenweise bestehen, welcher Umstand Bruno Schulz[2]) veranlasst hat, das Wasser in zwei Zonen einzuteilen, die obere — etwa 30 bis 40 Meter starke — in der die Assimilation und die untere, in der die Atmung überwiegt. Er benutzte als Indikator zur Unterscheidung derselben den Sättigungsprozent $100 \times O_2/O'_2$. Dass letzterer hierzu ungeeignet ist und zu falschen Schlüssen leiten kann, wurde schon dargetan. Um zu erfahren, zu welchen Ergebnissen man mit dem neuen Verfahren kommt, wurde das ganze frühere Sommermaterial mit Stickstoffanalysen durchsucht, leider konnten aber nicht mehr als drei Punkte mit $100 \times O_2/O'_2 > 100$ gefunden werden, die auch in der Tabelle 3 aufgenommen sind (Skagerrak und Nordsee, August).

Die Werte dieser Punkte, sowie auch die sämtlicher übrigen, die an Sauerstoff untersättigt waren, ergeben wiederum, dass der Stickstoffsättigungsgrad sowie $100 \times O_2^N/O'_2$ höher als der Sauerstoffsättigungsgrad war, und das $O_2^N > O_2$ m. a.W., dass die Respiration und nicht die Assimilation überwog. Das Resultat ist somit das gleiche wie für die übrigen Jahreszeiten, weshalb wir als Ergebnis der Durchsicht des ganzen zugänglichen Analysenmaterials von 1898 bis 1905 feststellen können, dass das Oberflächenwasser im Ostseebecken sowie in der Nordsee und auch im Atlantischen Ozean und im Eismeer, soweit das wenige Material ein Urteil zulässt, an Sauerstoff stets untersättigt war, wenn der Sauerstoffgehalt auf denjenigen Gehalt O_2^N bezogen wurde, der vorhanden gewesen wäre, wenn keine biologische

[1]) Die zweite Stelle war das Seite 181 in der Fussnote erwähnte Oberflächenwasser von F 64 1898 XII 11 mit $O_2^N - O_2 = -0{,}4$ cm³, dessen N_2-Zahl offenbar fehlerhaft ist.

[2]) Bruno Schulz: Die Durchlüftung der Nord- und Ostsee, »Die Naturwissenschaften«, 1924, Heft 6. S. 106—108.

Einwirkung stattgefunden hätte, dass also auch in der Oberfläche die Respiration von Seiten des Tierplanktons stets die Assimilation von Seiten des Phytoplanktons überwog. Darauf, dass dieses trotzdem nicht immer und überall der Fall zu sein braucht, wurde bereits hingewiesen. Von Interesse wäre es, die Verhältnisse im Ozeanwasser kennen zu lernen, speziell z. B. zur Zeit der Diatomacéenblühte, welches Studium also Bestimmungen sowohl des Sauerstoff- als des Stickstoffgehaltes voraussetzt, am besten kombiniert mit Planktonentnahme. Da das Pflanzenplankton nur dort zugegen ist, wo ihm die nötigen Nährstoffe zu Gebote stehen, von denen die im Meerwasser gelösten Stickstoffverbindungen und Phosphate am wichtigsten sind, so wird die Frage der Sauerstoffübersättigung auch in Beziehung gebracht zu der Frage über das Vorkommen der letzteren Stoffe.

Die vorliegenden Darlegungen haben, wie ich hoffe, die Anwendbarkeit des Begriffes des biologisch unbeeinflussten Sauerstoffs dargetan, und dabei zu Resultaten geführt, die die Förderung nicht nur rein hydrographischer Fragen erlauben sondern auch gewisser biologischer, welche im nahen Zusammenhang stehen mit der Frage über die allgemeine Produktions-Konsumtionsbilanz im Meere. Eine Behandlung der Verhältnisse in der Tiefe steht noch aus. Das weitere Vordringen verlangt aber durchaus ein Wiederaufnehmen der Stickstoffanalysen.

Summary.

The present paper describes a method of utilising for hydrography analyses of the gaseous oxygen and nitrogen content of sea-water to greater advantage than has hitherto been possible. Analyses of the nitrogen content of sea-water were made only during the first years of the international exploration of the sea, and then with the object of determining the temperature at which the water had originally been saturated with air. The nitrogen analyses were, however, given up after Professor Martin Knudsen had shown that the method employed led to erroneous results. Thenceforward the oxygen determinations were made according to the volumetric method of Winckler-Bjerrum. By employing, however, almost the same principle as in the determination of the absorption temperature, a more valuable hydrographic utilisation of the nitrogen determination may be obtained, if it is combined with oxygen determination. The solubility in water differs for nitrogen and oxygen, and varies with the temperature and the salinity. It takes a very similar course in both cases, however; hence the ratio of the absorption coef-

ficients corresponding to each other varies but slightly. It also follows from this both that the nitrogen and the oxygen content of sea-water will run fairly parallel provided none but purely physical influences, such as the mixing of water of different temperatures and different salinities, assert themselves. It is a well known fact that this does not hold good for oxygen, which may be greatly altered by biological influences, whereas it is true for nitrogen. And this latter circumstance is utilised to calculate from the nitrogen content the oxygen content which would have been present if no biological influence had made itself felt. Let this oxygen be the biologically uninfluenced oxygen and let it be denoted by O_2^N. The calculation is made according to the following principle by means of Chas. J. J. Fox's Tables. If the water is just saturated with nitrogen, the oxygen figure corresponding to the observed chlorine and temperature figures may be read directly from the Table. For the most part, however, the nitrogen content of the water does not correspond exactly to the content at saturation, which means that the N_2-, Cl-, and temperature values given in the Table do not correspond exactly to the values actually found in the water. One of the three values observed must then be disregarded. Calculations have shown that this cannot be the nitrogen, while with regard to the other two variables it has been found that smaller average errors occur in the calculation of O_2^N if the temperature value be disregarded rather than the chlorine value. The proceeding is then as follows. Independently of the observed temperature, the temperature value which, with the observed chlorine value, gives the observed nitrogen value is looked up in Fox's Nitrogen Tables. The oxygen value (in the Oxygen Tables) corresponding to these latter chlorine and temperature values will then indicate the oxygen content O_2^N. To avoid the double interpolations necessitated by these operations, Table 1 was drawn up, containing the ratios of the absorption coefficients O_2/N_2 with the N_2 and Cl values as arguments. Simpler still is the graphical method shown in the diagram in Fig. 1, by which O_2^N can be directly interpolated from the N_2- and Cl-values. For practical purposes the diagram must be drawn on millimetre paper on the scale of 1 cm^3 N_2 and 1 cm^3 O_2 = 5 cm.

The circumstances are then discussed which produce variations in the gaseous content of the sea, and which may naturally influence the accuracy of the calculation. The effect of temperature and of salinity singly, and of both together is examined by means of various examples of mixtures. The calculations showed that, with the extreme values employed (t varied between 0° and 26°, and Cl between 0 and 20 $^0/_{00}$), O_2^N calculated from the nitrogen content deviated by 1.2 $^0/_0$ from the

correct value in the most unfavourable case. For ocean water, where it is in the main only the temperature which varies, the error will not exceed 0.5 %. Hence the method of calculation was considered reliable.

The newly introduced expression O_2^N renders it possible simultaneously to follow and balance against each other the biological and the physical influences on the oxygen content. The O_2^N value presents a reliable point of departure for estimating the "consumption of oxygen" as the difference between the biologically uninfluenced and the actual content of oxygen $O_2^N - O_2$. A positive consumption value means that respiration on the part of the animal organisms exceeds assimilation on the part of the plant organisms; a negative figure indicates that the opposite is the case. The consumption can also be expressed as an percentage: $100 \times O_2/O_2^N$. In Tables 2 and 3 earlier analytic material is treated in the ordinary manner and also used for the calculation of the new quantities introduced. $100 \times O_2\, O_2'$ gives the saturation percentage as hitherto employed[1]). The Surface Table (3) gives in addition the saturation percentage of the nitrogen $100 \times N_2/N_2'$, and of the biologically uninfluenced oxygen $100 \times O_2^N/O_2'$. The result was that, with this method, O_2 consumption could also be shown in the surface water, which had hitherto been impossible. A survey of the whole of the earlier material (not given here, see footnote at p. 168) showed, for the depths as well as for the surface, an excess of respiration over assimilation at all seasons of the year. With a more extensive material exceptions will probably be found. It would be of interest to make a special study of the subject. In addition, the tendency to over-saturation (see p. 173) resulting from the mixing of water of different temperatures was ascertained. These results confirm the hydrographic utility of the expression O_2^N, which might be put to more extensive use.

[1]) O_2' means according to general use, the oxygen content at saturation, corresponding to observed t°- and Cl-values.

A Frameless Reversing Waterbottle.

By

Martin Knudsen.

Polyteknisk Læreanstalt, København.

This waterbottle is intended for use with reversing thermometers similarly to the waterbottle with frame previously described (Publications de Circonstance No. 77, p. 9) and the Nansen waterbottle with stopcocks. The volume and weight of the new instrument are about

Fig. 1.

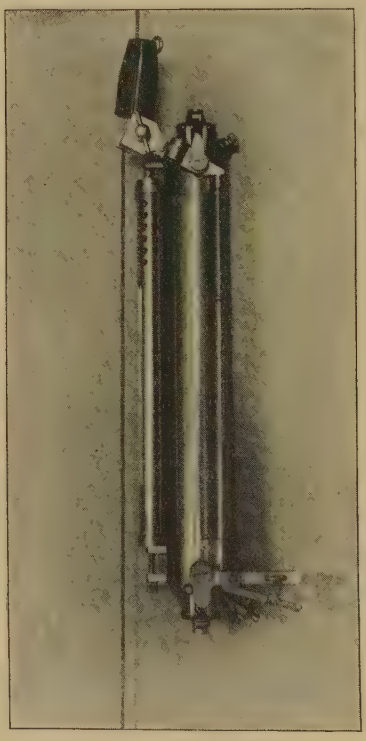


Fig. 2.

the same as those of the stopcock instrument, viz. 1.2 Liter and 3.3 Kilo (without thermometers). It is constructed with a view to using a number of instruments on the line at the same time, and consequently the price is kept as low as possible, viz., 150 Kr. with messenger and box.

The appearance of the waterbottle when hanging on the line ready to be closed and capsized is shown in fig. 1. Below the bottle is seen a messenger which is to go down to the next waterbottle and to effect the closing and capsizing of this latter; and so on. The waterbottle is first clamped to the line with the screw at the bottom, and then turned in the upright position and kept there by a small stop. The two thermometers are then fastened to the waterbottle with a single clamp, the two lids are opened, the messenger below is attached and the waterbottle is ready to go down into the water.

When a messenger is sent down the line it first hits the arm holding the stop. By the blow the stop is forced away, the messenger below is set free, the two lids close, pulled firmly together by a strong phosphorbronze spring inside the bottle. The strain in the line causes the capsizing of the bottle to commence, and the bottle swings round to the position shown in fig. 2.

When the lowest messenger has reached the lowest waterbottle on the line, the hauling up can begin. When the waterbottle comes up, the two thermometers may be very easily disconnected from the bottle if it is considered necessary to put them in a waterbath to secure uniform temperature. For emptying, the bottle is provided with a small stopcock at the bottom and an air screw at the top.

The waterbottle is nickleplated inside and out, and is very strongly built. Its special advantages should be easiness of use, no grease, no large stopcocks to watch and better passage for the water through the bottle than can be effected by the use of stopcocks.

A Maregraph for the open Sea.

By

Professor **Was. W. Shoulejkin.**

Moscow.

A great many scientists are now interested in the theory of the propagation of tidal waves and it would be a question of great importance to verify the cotidal lines determined by means of these theories. To solve the above mentioned problems in full these results would require investigating and testing in the open sea. But a standard maregraph can only work ashore and is not fitted to register tidal waves in the open sea.

The excellent instrument constructed by HONDA has much helped the Japanese investigators, for it can be used in the open sea, though under special conditions on board a motionless vessel such as a light-vessel; it cannot be used, however, at any great depth.

As to FAVÉ's maregraph, though very cleverly constructed, its mechanism is so complicated that it requires special care in handling. This instrument can be used only at very limited depths too, and it is very difficult to adjust the registering parts and to interpret its record.

To avoid all these defects I have designed a new type of maregraph. It was constructed at the workshops of the Moscow Institute of Physics and Biophysics, for the Polar Expedition of the Maritime Scientific Institute. The second model of the apparatus is built for the Hydrophysical Department of the Institute of Physics mentioned above.

We shall be able to judge of its efficiency only when sufficient material with regard to its working has been furnished by the expedition. But its construction is so simple, that there can be no doubt as to its usefulness.

The most characteristic feature of this new type of maregraph lies in the fact that it does not respond to the absolute hydrostatic pressure

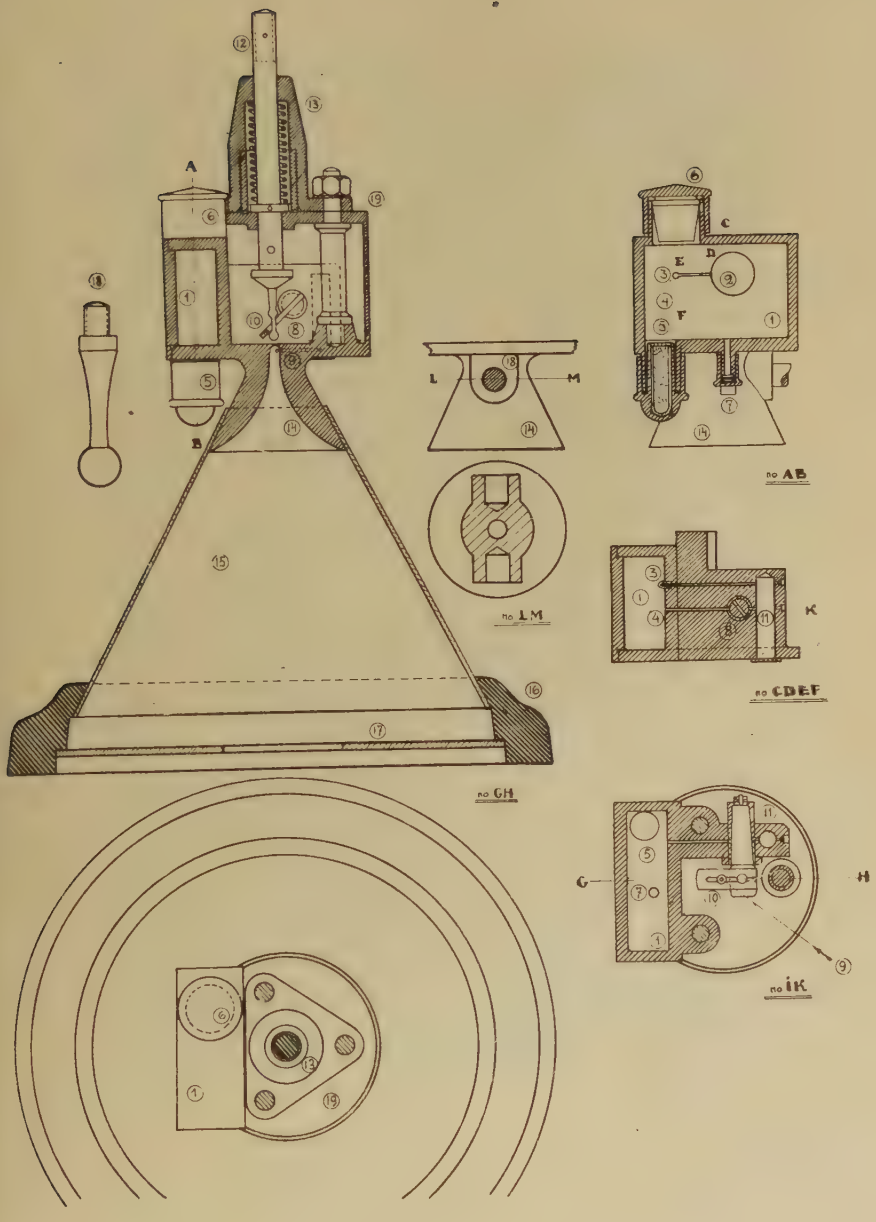


Fig. 1.

at the depth at which it is placed, but registers only the changes of hydrostatic pressure caused by the tidal wave.

Before the apparatus is immersed it is not necessary to know the depth of the bottom at the given position; it is only desirable to know the limiting depth at which the measurements will be undertaken.

My first model was made to suit a depth of 300 meters, the aim of its construction being work in the Barents Sea. But there is no difficulty whatever in constructing a maregraph suitable for working at any given depth. Only its size needs slight alteration.

It is very important to note, that this alteration concerns only the simplest part of the apparatus. The most important part of the instrument, that is, its recording part, remains unchanged and is standard for any depth.

Fig. 1 gives a series of detailed sections explaining the working of the instrument. Fig. 2 represents a photograph taken of the first model with its front cover open to show the recording mechanism.

The recorder seen in Fig. 2[1]) represents an ordinary pocket altimeter (Barographe Altimétrique de Poche. Système J. Richard) with only one alteration. This alteration concerns its aneroid-box "2" (see Fig. 1) which has an additional tube "3" soldered to an apperture in its side. Through this apperture the box was filled with air and afterwards the spring so regulated as to make the pen assume a position just in the middle of the paper roll when in normal conditions.

No other details of the chamber "1" were given in Fig. 1, in order to make the design as clear and distinct as possible.

The tube "3" opens at its other end into a vertical canal "11" which is connected with the inner space of the bell "15" by means of a very narrow canal "9" that is bored through the top of the cone and the disc "9" above it.

But besides this canal "3" another very narrow canal "4" with a valve "8" opens into the vertical canal "11". When this valve "8" is open, it establishes connection between the space "15" under the bell, and the chamber "1" in which the recorder is fixed. Therefore, the external pressure on the sensitive box is equal to the internal pressure.

The opening and closing of the valve "8" is effected automatically by means of the rod "12". In the process of lowering the maregraph is suspended on a ring fastened at the position "12"; the spring "13" becomes compressed by the weight of the instrument itself, then the

---

[1]) Just before the photograph was taken the paper roll had been put by mistake with its upper part down, which caused the curves to be turned in the wrong direction.

rod is raised and the valve "8" opens and remains open during the whole process of lowering.

Under the influence of the hydrostatic pressure the air under the

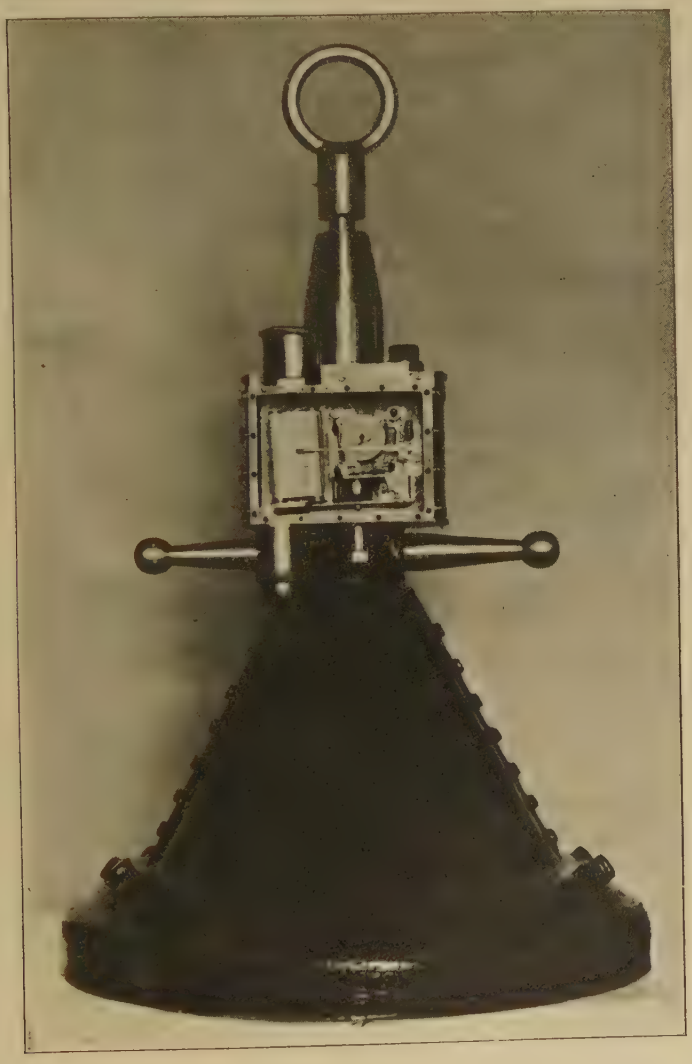


Fig. 2.

bell "15" becomes more and more compressed. The external and internal pressures on the walls of the camera "1" remain equally balanced. The internal pressure in all the other parts of the instrument is always equal to the external pressure and therefore one has nothing to fear in regard to the watertight condition of different covers and joints.

Now let us see what happens when the maregraph reaches the bottom of the sea. The very moment it touches the bottom, the spring "13" will cause the rod "12" to rise, which will result in the closing of the valve "8". From this very instant the membrane of the recording chamber "2" begins to answer to the variations of the outside hydrostatic pressure caused by the tide.

While working with an expedition it will be necessary to leave the instrument lying at the bottom for a period not less than 24 hours. That enables a mechanism to be used which will make a full revolution in either 12 or 24 hours. In the first case the paper can pass twice under the pen. This will not confuse the record, for a tidal period lasts more than 12 hours.

At the end of the above mentioned period the boat has to approach the buoy to which is fastened the rope holding the maregraph. The very moment the bell detaches itself from the bottom, the spring "13" is compressed by the weight of the instrument, the valve "8" opens and connection between the chamber "1" and the outside is established. Therefore all the time the maregraph is being hauled up the decrease in hydrostatic pressure will not affect it, as the air under the bell will expand and in due time expel the water from it.

The sensitivity of the instrument depends chiefly on the box "2" which has to be chosen according to the amplitude of the tidal waves likely to be experienced. The above described model is suitable for recording waves with amplitudes attaining 3.3 meters. The altimeter used was designed for a limiting height of 2500 mt. above sea level.

To prevent the access of water to all its different and delicate parts (such as covers and junctions of the different parts of the mechanism) one must always bear in mind the limiting change in pressure which can be endured. To make it as safe as possible the front cover of the chamber "1" is screwed down and soldered up with Wood's fusible brass.

To prepare the maregraph for lowering one has to carry out the following simple operations:

1) Unscrew the covers "5", "6", and "7".
2) Push aside the clips on which the paper is fastened (for this purpose there is a special handle under them).
3) Through the apperture "6" extract the old paper roll and put on a new one.
4) Introduce ink into the fountain pen through "6".
5) Wind up the mechanism of the recorder through "7".

6) Change the calcium-chloride inside the glass capsule placed in the cover "5" (this capsule serves to dry the air inside the chamber "1" containing the clock mechanism).

After these operations all the covers of the instrument are to be tightly screwed up (to make them watertight all should have leather washers on them). We shall later endeavour to diminish the number of covers mentioned above.

As one can easily see the handling of this instrument does not require special care or knowledge. The size is not unduly large. The first model prepared for investigations at a depth of 300 mt. has a bell only 32 cm. high. To construct a maregraph for a depth of 3000 mt. it would be necessary to make the bell "15" 34 cm. higher. The top of the bell holding all the vital parts of the mechanism would remain the same.

Le Thon Rouge (Thunnus Thynnus L.) en Mer du Nord et dans l'Atlantique Nord Est.

Par

J. Le Gall.

Directeur du Laboratoire de l'Office Scientifique et Technique des Pêches Maritimes, Boulogne-sur-Mer.

La présence périodique du Thon Rouge (*Thunnus Thynnus* L.) en Mer du Nord et dans l'Atlantique Nord Est s'est encore confirmée au cours des deux dernières années 1927—1928.

Leur apparition a pu être constatée, de Juin à Décembre, aux lieux et époques où nous les avons déjà signalés[1]), et, principalement: sur la côte Sud Ouest d'Irlande, au large des Blaskets, en Juillet; sur la côte Nord d'Irlande (Klondyke Grounds) où ils furent particulièrement abondants en Juillet et Août 1928; sur la côte Ouest d'Ecosse en Juillet, sur les côtes Sud et Ouest de Norvège de Juillet à Octobre, dans le Skagerack et le Kattegat, aux mêmes dates; et enfin, en Mer du Nord, au large de la côte Est d'Angleterre: de Juillet à Octobre. En Novembre et Décembre, les chalutiers travaillant sur la Grande Sole, aux accores du plateau continental, pouvaient les rencontrer par bandes s'ébattant en surface.

En l'absence de toute statistique assurant le dénombrement exact des thons rouges débarqués dans les principaux ports de pêche, il n'est guère possible de fixer, même approximativement, la quantité de ces poissons ramenés, chaque année, à terre. Ce n'est donc qu'une impression générale, résultat de la lecture des rares informations parues sur ce sujet ou des constatations faites sur les lieux de pêche par les pêcheurs eux-mêmes et recueillies par l'Auteur, que celui-ci prétend rapporter: Au cours de l'été 1928, les thons rouges furent relativement abondants

[1]) J. LE GALL. Contribution à l'étude de la biologie du Thon Rouge (*Thunnus Thynnus* L). Sur la présence de Thons rouges en Mer du Nord et dans l'Atlantique Nord-Est. — Journal du Conseil International pour l'Exploration de la Mer. Vol. II. No. 3. Décembre 1927.

en Mer du Nord, plus abondants qu'en 1927, où ils avaient été constatés en moins grand nombre que l'année précédente 1926, et également plus nombreux qu'en cette année 1926. C'est encore aux mêmes lieux, et sur les pêcheries harenguières, qu'ils furent principalement rencontrés: d'abord dans l'Est et le Sud de l'Ile Fair en Juillet et Août, puis au Nord—Ouest du Dogger Bank et surtout sur le Brucey Garden, sur le bord Ouest du Dogger, en fin de Septembre et au début d'Octobre. A la même époque, ils apparaissaient encore abondamment dans le Sud du Dogger jusqu'à l'Upper Scruff.

Il n'apparaît pas encore que ces gros Scombres atteignent la partie méridionale de la Mer du Nord et dépassent le Smith Knoll vers le Sud: aucune apparition de thons rouges n'ayant encore été signalée au Sud de ce point. Cependant, un exemplaire débarqué à Boulogne, le 12 Novembre 1927, nous a été signalé comme capturé sur la pêcherie harenguière, au large de Boulogne, au Nord du Vergoyer. Cette information demande à être confirmée: la présence de thons rouges dans cette région serait en effet, extrêmement importante, car elle nous permettrait de considérer comme possible que les thons rouges dont la présence est constatée dès Juillet en Mer du Nord, dans les parages de l'Ile Fair, puis, de plus en plus au Sud à mesure que s'avance la saison, rejoindraient vers Novembre les eaux atlantiques aux accores du plateau continental en empruntant (tout au moins une partie d'entre eux) les couches profondes de la Manche pour reparaître en surface, un peu plus tard, dans les parages de la Grande Sole. Nous avons déjà signalé, à ce sujet, la capture faite par un chalutier boulonnais, dans la fosse de la Hève en fin de Novembre 1921, ainsi que la présence abondante de thons rouges, en surface, en Novembre—Décembre dans les parages de la Grande Sole, de la Petite Sole et du Banc de la Chapelle.

En Juillet et Août 1928, les gros thons rouges furent particulièrement abondants dans le Nord de l'Irlande, sur les pêcheries dites du Klondyke Irlandais ou d'Inishtrahull. Dans cette région des quantités de harengs se rassemblent sur les fonds et ces bancs sont activement recherchés par les chalutiers anglais, allemands, belges et français. Nous y avions déjà signalé la présence de thons rouges en 1926. L'an dernier ils furent en telle abondance que les chalutiers en capturèrent non seulement au harpon, quand ils venaient s'ébattre en surface, mais encore, et à de fréquentes reprises, pris dans les mailles du chalut (Exemple du Chalutier allemand »Königsberg« ramenant quatre thons à la fois dans son chalut en fin de Juillet 1928, sur les Klondyke's Grounds).

Les conditions hydrologiques sur les lieux de pêche du Thon Rouge en Mer du Nord.

Il apparaît actuellement, d'un façon absolument certaine, que la présence abondante de thons rouges, en certains points de la Mer du Nord et ses dépendances est conditionnée par un facteur important, la présence d'une nourriture abondante. Le même facteur joue d'ailleurs le même rôle important dans les autres régions de l'Atlantique Nord-Est où purent être rencontrées des bandes de thons rouges: que ce soit au large des côtes anglaises en Mer du Nord, sur la côte de Norvège, dans le Skagerack ou le Kattegat, sur la côte Ouest d'Ecosse, au large d'Inishtrahull, aux Blaskets, à Smalls, ou à la Grande Sole, là où furent signalés ces thons pendant leur période de dispersion trophique, là étaient signalées simultanément la présence abondante de poissons pélagiques (harengs, maquereaux, sardines) ou autres.

Mais, ainsi que nous l'avons déjà fait remarqué avec H. Heldt, d'autres facteurs encore plus importants et d'ordre hydrologique conditionnent leur déplacement. Il apparaît, en effet, non moins nettement que l'arrivée de ces thons rouges dans le domaine continental, c'est-à-dire en deçà de la limite du plateau continental, coïncide avec l'extension sur ce domaine des eaux atlantiques ou plus exactement des eaux de pente atlantique.

Quelques stations hydrologiques faites au cours des croisières de la »Sentinelle« et de »l'Estafette« pendant les campagnes harenguières de 1927 et 1928, aux endroits mêmes où étaient rencontrés des bandes de thons, viennent confirmer ces faits.

Ces stations sont les suivantes:

31 Juillet 1927.

Latitude 57°38′ Nord. Longitude 0°23′ Ouest Gr.

Température: surface ..... 16°

— 10 mètres..... 14° Salinité 34,92 ‰

10 Août 1927.

Latitude 55°56′ Nord. Longitude 1°02′ Ouest Gr.

Température: surface ..... 15°5′

— 20 mètres..... 15°5′ Salinité 34,75 ‰

26 Août 1927.

Latitude 54°30′ Nord. Longitude 0°45′ Est Gr.

Température: surface ..... 16°5′

— 25 mètres..... 11°5′ Salinité 34,54 ‰

— 50 mètres..... 9°5′ — 34,57 ‰

29 Août 1927.

Latitude 54°41′ Nord. Longitude 0°42′ Est Gr.

Température:	surface	15°		
—	10 mètres.....	15°		

30 Août 1927.

Latitude 54°54′ Nord. Longitude 0°55′ Est Gr.

Température:	surface	15°5′	Salinité	34,58 ‰
—	20 mètres.....	15°	—	34,60 ‰

5 Septembre 1927.

Latitude 54°32′ Nord. Longitude 1°17′ Est Gr.

Température:	surface	15°		
—	25 mètres.....	14°		

16 Juillet 1928.

Latitude 58°16′ Nord. Longitude 0°16′ Est Gr.

Température:	surface	11°7′	Salinité	34,70 ‰
—	50 mètres.....	6°7′	—	34,70 ‰
—	160 mètres.....	6°4′	—	34,94 ‰

24 Juillet 1928.

Latitude 58°21′ Nord. Longitude 0°40′ Est Gr.

Température:	surface	12°3′	Salinité	34,99 ‰
—	50 mètres.....	7°0′		
—	160 mètres.....	6°8′	—	34,98 ‰

18 Août 1928.

Latitude 54°57′ Nord. Longitude 0°34′ Est Gr.

Température:	surface	15°0′		
—	20 mètres.....	14°5′	Salinité	34,58 ‰

1 Septembre 1928.

Latitude 54°35′ Nord. Longitude 1°15′ Est Gr.

Température:	surface	14°0′		
—	20 mètres.....	14°0′	Salinité	34,53 ‰

On constatera que la salinité de ces eaux varie dans de faibles limites de 34,50 à 35 ‰. Ce sont des eaux de transgression, mais non des eaux atlantiques vraies dont la salinité est supérieure à 35 ‰. On se rappellera d'ailleurs que le Hareng se tient à la limite de ces eaux atlantiques, sans y pénétrer, et qu'il participe à leur mouvement en reculant à mesure qu'elles avancent (Le Danois); et ceci explique la présence simultanée,

dans les mêmes eaux, du hareng et du thon, ce dernier tributaire des eaux atlantiques dont le voisinage lui permet de rapides incursions dans la zone limite des eaux atlantiques et continentales.

Le Thon Rouge a t'il toujours fait partie de la faune normale de la Mer du Nord?

Il est bien entendu qu'il ne peut être question ici que de la présence temporaire, mais néanmoins régulière, du thon rouge en Mer du Nord et ce, pendant les mois d'été et d'automne, au moment où la transgression atlantique se fait sentir dans ce domaine.

Mon excellent ami et prédécesseur à la Station de Boulogne sur Mer: H. Heldt, à qui revient tout le mérite d'avoir attiré l'attention des biologistes sur cette question, ne semble pas devoir étendre la périodicité de leur apparition aux temps passés et croit plutôt à une extension récente de l'habitat de ces Scombres en Mer du Nord, conditionnée par un afflux plus important des eaux salées atlantiques dans cette région. Pour H. Heldt, 1907 marque la date d'apparition du thon rouge sur le Dogger Bank en Mer du Nord.

J'ai pu apprécier déjà l'esprit scientifique de mon ami Heldt pour être certain qu'il ne m'en voudra pas de remettre la question en discussion et de ne pas partager son opinion. Ceci pour les raisons suivantes: a) Les thons rouges (*Thunnus thynnus* L.) ont précédemment été signalés en Mer du Nord, au cours du 19ème siècle, à différentes reprises et en quantités importantes.

Labille[1]) cite à propos de *Thynnus vulgaris*: »Les pêcheurs disent qu'ils en rencontrent parfois des bancs en marche«.

D'après P. J. van Beneden: »on en voit sur la côte du Jutland et il est assez commun en Norvège pour avoir un nom vulgaire à Christiania (Suède actuelle). On en cite aussi des captures sur la côte des Pays Bas.«

Ces termes sont repris par H. E. Sauvage[2]) dans son Catalogue des Poissons des côtes du Boulonnais (1888).

Giard[3]) analysant ce catalogue en 1888, met cependant en doute la présence réelle de *Thunnus thynnus* et croit à une confusion avec *Thynnus pelamys* (*Pelamys sarda*) que Bottemanne cite comme rare

---

[1]) Labille. Les bords de la Mer. Boulogne 1858. p. 193.

[2]) H. E. Sauvage. Catalogue des Poissons des côtes du Boulonnais. — Bul. Soc. Zool. France 1888. p. 142.

[3]) A. Giard. Observation sur le catalogue des Poissons du Boulonnais. — Bull. Scient. France et Belgique. 1888. T. XIX. p. 457.

parmi les poissons de l'Escaut de l'Est. Il y revient en 1889[1]) et reconnaît en citant P. J. van Beneden que ce doute n'était pas fondé.

»Il y a deux ou trois ans, à Ostende, un marchand de coquillages me dit que les pêcheurs venaient de lui vendre la tête d'un animal qui ne devait pas avoir moins de quatre à cinq pieds, et qu'ils avaient pris dans le chalut, aux environs du Dogger Bank. En comparant cette tête dépourvue des parties molles au squelette du thon du musée de Louvain[2]) qui m'avait été envoyé par Eschricht, je reconnus de suite qu'il s'agissait d'un *Thynnus vulgaris*«.

Et Van Beneden cite encore de précédentes captures qui pourraient s'ajouter à la liste que nous avons précédemment publiée.

De plus, maintenant que le thon rouge fait l'objet de transactions vives sur le marché, les souvenirs se précisent dans la mémoire des vieux pêcheurs boulonnais, et une enquête près d'eux nous a permis de constater qu'ils reconnaissent »avoir toujours vu ces gros poissons«, mais, »qu'ils ne savaient pas comment les capturer« et, pour préciser une date, l'un d'eux; le Patron Delpierre du »Petit Poilu«, nous conta ses premiers essais malheureux pour capturer ces »gros poissons qui venaient prendre le hareng le long du bord«. Or ces essais se placent avec certitude pendant la campagne harenguière de 1897. Les pêcheurs boulonnais ont appris depuis à capturer le thon et pour nous, 1907 marque simplement la date d'un premier essai, fructueux au delà de toute espérance étant donné les cours élevés rapidement atteints par ce poisson, et aussitôt suivi: le Jean Bart ramenant dès l'année suivante, 1908, 14 thons capturés au cours d'une sortie sur les pêcheries harenguières. b) Les conditions d'ordre hydrologique (extension des eaux salées atlantiques) qui expliquent leur présence actuelle en Mer du Nord offrent également des arguments probants en faveur de leur présence dans le passé.

Nous sommes parfaitement d'accord, Heldt et moi, pour admettre que l'arrivée des thons rouges en Mer du Nord coïncide avec l'afflux dans ces régions des eaux de transgressions atlantiques.

Or ce phénomène transgressif, confondu avec les marées profondes, provoqué par les mêmes causes d'ordre astronomique, en présente les mêmes rythmes reconnus et établis par les travaux de Pettersson, Storrow, d'Arcy Thompson et Le Danois. Ce phénomène ne date pas de 1907, et si l'on veut admettre des causes d'ordre purement hydro-

---

[1]) A. Giard. Sur la présence du Thon (*Thynnus vulgaris* L.) dans la Mer du Nord. — Bull. Scient. France et Belgique 1889. T. XX. p. 178.

[2]) Squelette provenant d'un thon capturé sur la côte du Jutland.

logique dans l'extension de l'habitat dès thons rouges en Mer du Nord, il faut reconnaître que les mêmes causes ont permis ce même fait dans le passé.

Il est de plus reconnu que les thons rouges voyagent toujours par bandes plus ou moins nombreuses, même au cours de leur période de dispersion trophique. Si quelques exemplaires isolés ont pu être signalés par les différents auteurs au cours du 19ème siècle, il est de toute évidence, qu'au large de la côte, ces individus étaient plus nombreux. Or, c'est précisément aux époques des grandes transgressions atlantiques dont les maxima ont été: 1795, 1813, 1831, 1849, 1866, 1885, 1904, 1921 que ces exemplaires nous sont signalés. Il y a tout lieu de croire qu'ils furent abondants au cours de ces années.

Ceci ne revient pas à dire que ce soient les seules années où les thons ont pu pénétrer en Mer du Nord. La transgression annuelle se fait chaque année sentir en Mer du Nord avec une importance plus ou moins grande et suivant le rythme connu. S'ils devaient disparaître avec la transgression, c'est-à-dire à mesure que celle-ci diminue d'importance, leur nombre aurait dû diminuer depuis 1921 (année de transgression maximum) et on aurait tout lieu de craindre leur disparition pour l'année prochaine 1930 (année de transgression minimum). Les fortes pêches réalisées au cours de la dernière saison (précédant seulement de deux ans une année de transgression minimum) nous incline à penser qu'il n'en sera rien et que le thon ne désertera pas encore la Mer du Nord.

Nous persistons donc à croire que le thon rouge a toujours pu faire partie de la faune normale de la Mer du Nord en tant que visiteur annuel, de Juillet à Octobre, quand les conditions hydrologiques: influx des eaux atlantiques dans ce domaine, lui permettent cette extension de son habitat.

Nous admettons, toutefois, que leur abondance peut être largement influencée par le rythme régulier des transgressions atlantiques dont l'influx plus ou moins important, sur le plateau continental de la Mer du Nord, leur permet une dispersion plus ou moins étendue dans cette région.

A new Method of Treating Frequency Curves in Fishery Statistics, with some results.

By

H. J. Buchanan-Wollaston and **William C. Hodgson.**

Fisheries Laboratory, Lowestoft.

The method which is the subject of the present paper is the result of carrying a certain train of ideas to its logical conclusion. The ideas themselves are at any rate not entirely new, and have certainly arisen independently in the minds of many fishery statisticians, but there does not seem to be any published account of their application and development into a definite method. Their applicability depends on treating each sample of fish measurements separately, or on treating together only such data as are limited to a very restricted "area" in time and space. In the past it has generally been assumed that the most useful statistical pictures of length frequency distribution and growth-rate are to be obtained by treating very large samples, and by a considerable amount of combination of samples ranging over a not very restricted time-space area. The "roughnesses" in the data, which have generally been considered to be due to insufficient sampling and to slight errors in measurement, are thus smoothed out, and the resulting smooth curves have been considered to give a more generally correct picture than the original rough data. The present method is founded on a fundamentally different set of assumptions, and the results are fundamentally different. If these are correct, the statistical "constants" given by the usual method are quite incorrect and the "mean size", "standard deviation from the mean", and other constants in general use are conventional symbols only and mean nothing really definite. "Growth-rate" if calculated from these constants will be meaningless since it is calculated from the growth-rate of different populations on the assumption that the same population is dealt with throughout. It will be shown in the following pages that there is strong evidence that the "roughnesses" in the original data of fish measurements, however

small the samples may be, are significant. The new method has been exhaustively tested by us on measurements of quite small samples of plaice caught in an inshore trawl in the Poole district, and on measurements of drift-caught herring. It is thus applicable to the measurements of two widely differing kinds of fish caught by entirely different methods, and is probably generally applicable except in cases where intermingling of populations is very intense.

The application of the method to the rough measurements of white-bait-herrings, and to the calculated length l_1 from the scales of adult herrings has already done much to clear up the problem of the composition of the Autumn shoals of the Southern Bight. It has also shown, beyond doubt, that LEE's phenomenon of apparent decrease in growth-rate is an illusion, and that instead, the calculated length l_1 from the scales is almost in absolute agreement with measurements of herrings of the "O"-group in winter, and further, that calculations made on a single year-class are constant from year to year. Observations carried out on herrings born in the winter 1921—22 showed that the position of the mode of the group was 7.6 cms. when two years old, and 7.7 cms. when seven years old. Later, several instances of the use of this method will be given with reference to the data of other workers, and many further examples will be found in reports on plaice and herrings, which are in the course of preparation and which will shortly be published.

The style in which the method is set forth may appear somewhat dogmatic. This is due to the desire to formulate a procedure as a definite method. It expresses a definite point of view, and it is a simplification to treat it here as invariable.

Description of the Method and its Application to Plaice Data.

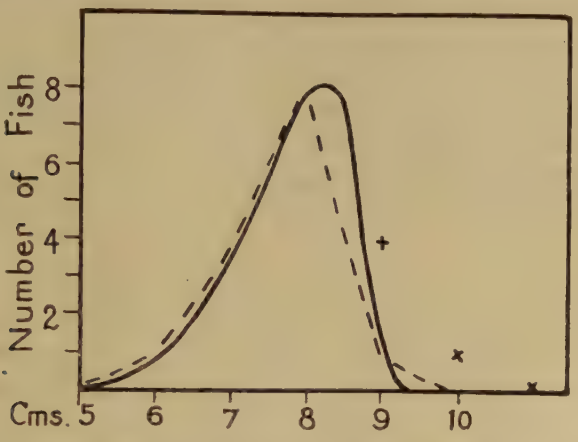
By *H. J. B.-W.*

Length frequency curves of fish measurements drawn from samples limited to a very small time-space area are, with certain definite exceptions, almost invariably either markedly skew or very irregular and jagged having several closely adjacent maxima. The exceptions are the following:— frequency curves of the youngest year-groups in certain fish, taken at one time and in a very restricted area, and certain catches made with drift nets.

In addition to the skew and "jagged" curves, curves of intermediate shape occur frequently, showing one or more "humps" on one or on both sides of the main curve. Figs. 1, 2 and 3 show frequency groups illustrating the three types mentioned, the points corresponding to the numbers at each length being joined by straight lines. Fig. 1 represents a catch

of plaice of the 0-group taken in a small trawl in Poole Harbour in August 1924; Fig. 2, measurements of all plaice of the I-group taken during May 1925 in the Poole district, and Fig. 3, corresponding measure-

Fig. 1.



ments for June 1925. The curve shown in Fig. 1 does not appear on the surface to be compound, but is very skew. If it were symmetrical it would pass through the points connected by the dotted line.

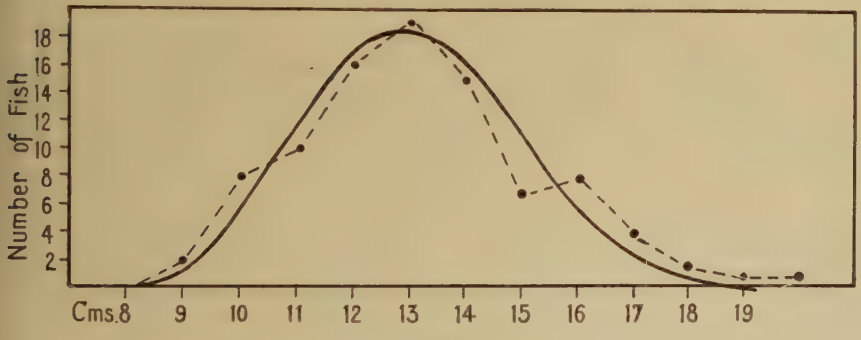


Fig. 2.

Fig. 2 shows a well-marked central maximum, a fairly well-marked secondary maximum on the upper side, a "hump" on the lower side of it.

Fig. 3 shows three well-marked maxima and a slight "hump" on the upper side of the highest of the three.

It is first desirable to discuss the view which it seems probable that every worker who has hitherto written on the subject of plaice ichthyometrics would take of these three frequency groups, judging from the methods which have hitherto been applied to the problem. It should be emphasized that each of our groups contains fish of one early age-

group only, and that our samples are very small ones, minute when compared to those used, for instance, in the ichthyometric work carried out for the Ministry of Agriculture and Fisheries in the North Sea. Undoubtedly then the generally accepted view would be that closely adjacent maxima in such small samples are insignificant, that the groups are probably skew and each have one main mode which might be obtained by smoothing the curves through the frequencies, and that the arithmetic mean sizes give the most useful pictures of the sizes of

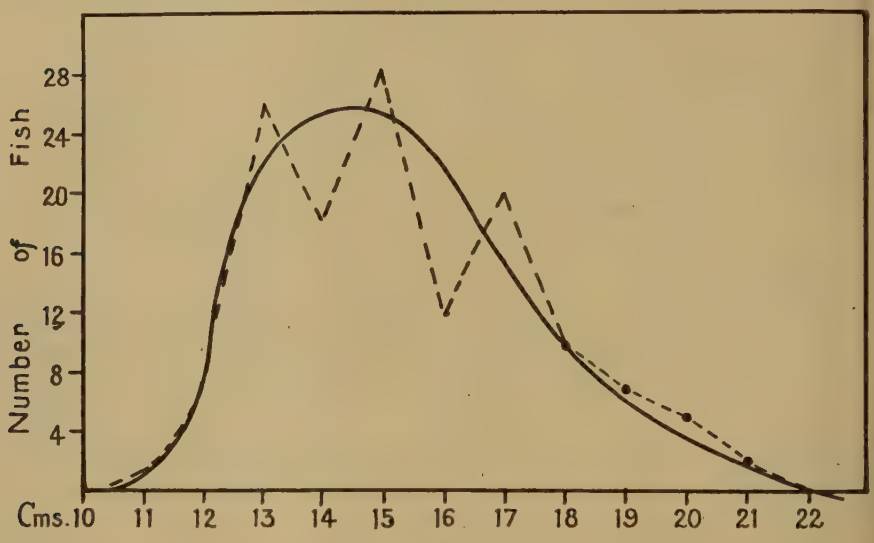


Fig. 3.

the groups as a whole. Indeed the view that each age-group has one main mode has been in the past so generally accepted that a method of age estimation, the Petersen Curve Method, has been in general use for the younger age-groups of fish, this method depending entirely on the assumption that each well-marked mode corresponds to an age-group. If we make the assumptions that frequency curves of fish measurements may be very markedly skew, and also that the comparative numbers in each size-group may be subject to very great chance variation — two assumptions made in the case of practically all past work of this nature when the samples have been small — we are justified in "smoothing" the frequencies, either by summing in larger, say 5 centimetre, groups[1]), by combining numerous observations from different grounds or

[1]) Of course the chosen group interval must be adapted to the size and growth-rate of the fish in question. For instance in the case of cod 5 cm. grouping may be quite allowable and does not appear to mask the real sub-modes. (Vide Graham 1929).

made in different months, or by one of the various other "smoothing" methods. I myself, when starting the attempt to calculate growth-rate of the plaice of the Poole district, tried the effect of smoothing the length curve for September by combining the frequencies for September 1922 and 1925. The result was a smooth unimodal curve but very skew. If we make the aforesaid two assumptions and use any of the wellknown smoothing methods on the curves in Figs. 1 to 3, we shall obtain curves similar to those in continuous line in those figures, that in Fig. 1 very skew, that in Fig. 2 nearly symmetrical but of very wide range, that

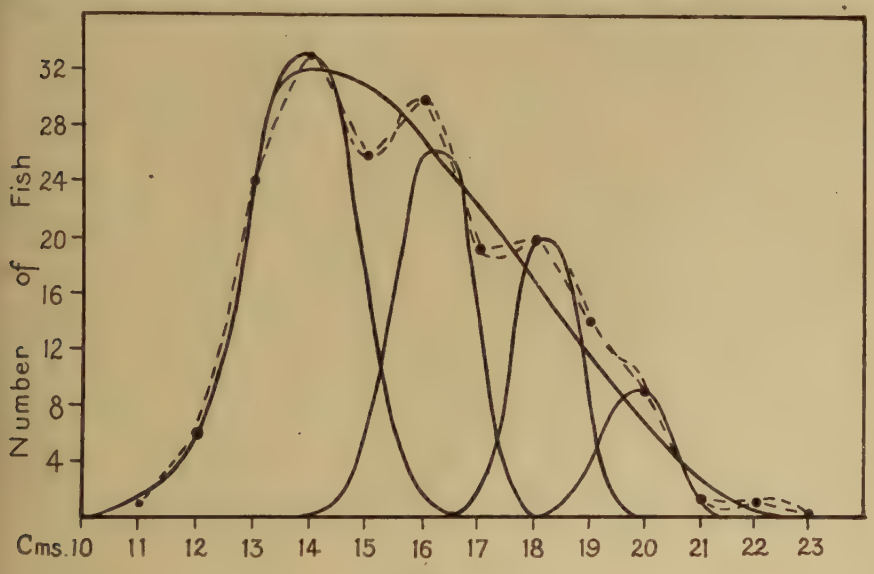


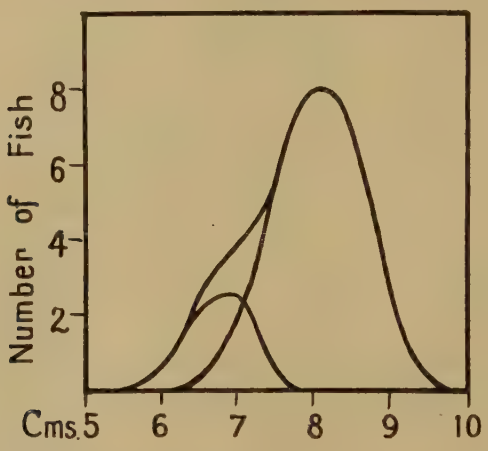
Fig. 4.

in Fig. 3 (June 1925) very skew, wide-topped and of wide range. On plotting the frequencies for July 1925 (Fig. 4) however, it was at once apparent that each maximum in June was represented by a maximum in July slightly advanced. A "smooth" curve near the frequencies in Fig. 4 would be somewhat of the shape of that in unbroken line, it would be extremely skew and of very wide range. The mode, assuming that there is only one chief mode, would be no higher, indeed, possibly lower than that for June, although each maximum in July shown by the rough frequencies is higher than the corresponding one for June. Now three or four maxima occur in the rough frequencies in August, September and October 1925, and it seemed an interesting experiment to treat the data from a new standpoint, to neglect entirely the two assumptions mentioned before, and to make the following assumptions (1) that every frequency curve of

fish measurements is compounded of several substantially symmetrical curves of narrow range and similar in shape to the Curve of Error (2) that every maximum shown in the rough frequencies corresponds to a real mode (3) that the comparative rough frequencies given by the data, even if very small in number, correspond sufficiently well with the actual frequencies of fish at each length on the ground, to be treated as absolutely correct with an insignificant error. That the component curves are Curves of Error or of similar shape is of course an assumption which is only justified if it is actually found that the compound curves may be built up from curves similar to the Curve of Error. Similarly the other assumptions can only be justified by results.

Before proceeding to apply a method of treating frequency curves

Fig. 5.



based on our three new assumptions it is necessary to have considerable practice in drawing symmetrical frequency curves of different ranges and heights. It is as well to choose the Curve of Error for this practice since this particular type of distribution is more frequently met with in nature than any other symmetrical type. The effect of this practice is that it becomes impossible to draw a curve widely differing from the said curve through frequency points without feeling a kind of mental strain. Practice in drawing any particular kind of mathematically continuous curve always gives rise to this mental criterion, and the establishment of critical faculty of this nature is an absolute necessity before dealing with curves on the lines developed in this paper. Having then developed this faculty of drawing Curves of Error freehand and also curves compounded from several Curves of Error of different heights and ranges and differently spaced apart, we first proceed to try and draw a Curve of Error through the points on our frequency distribution,

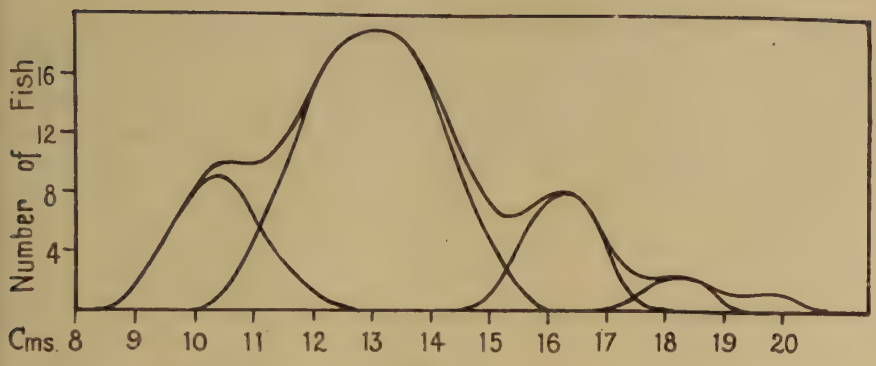


Fig. 6.

unless obviously impossible. If this cannot be done without a "feeling of strain" the curve must be regarded as compound and we now draw a compound of two or more Curves of Error through the points. Very little practice renders the drawing of these compound curves quite easy, as a rule they can be drawn in one way only, and to draw them is an immense help in the next step, the resolution of the compound curve into its constituents. Very small modes, or frequencies of one or two measurements only, lying at the ends of the compound curve should be neglected, since they do not belong to a group we are dealing with. Having drawn the compound curve, we now draw, freehand, Curves of Error which would seem to add up to the compound curve. The agreement is then tested at each ordinate, and the curves are adjusted

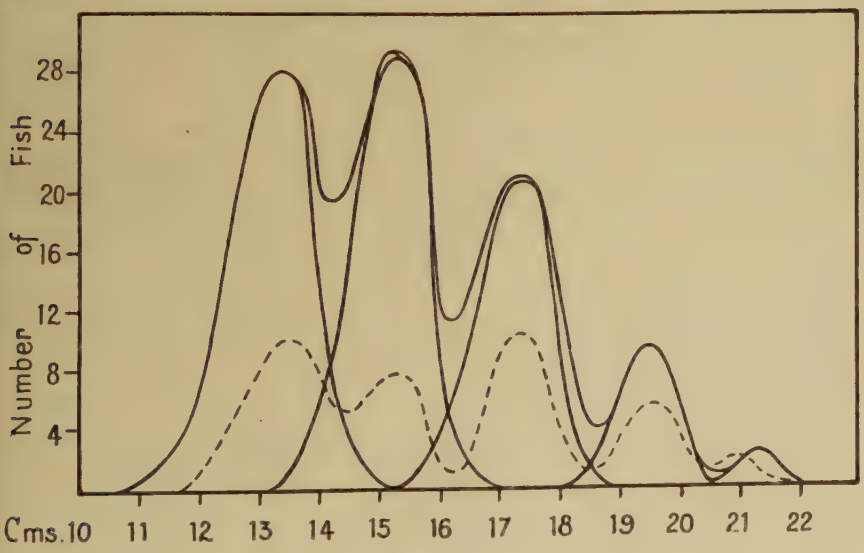


Fig. 7.

until the sum of the ordinates of the components is equal to the ordinate of the compound at each abscissa. This sounds a lengthy proceeding but it is not so in reality, particularly since extreme accuracy is usually quite unnecessary. The method even if only roughly applied gives the positions of modes within a quarter of a centimetre, and this degree

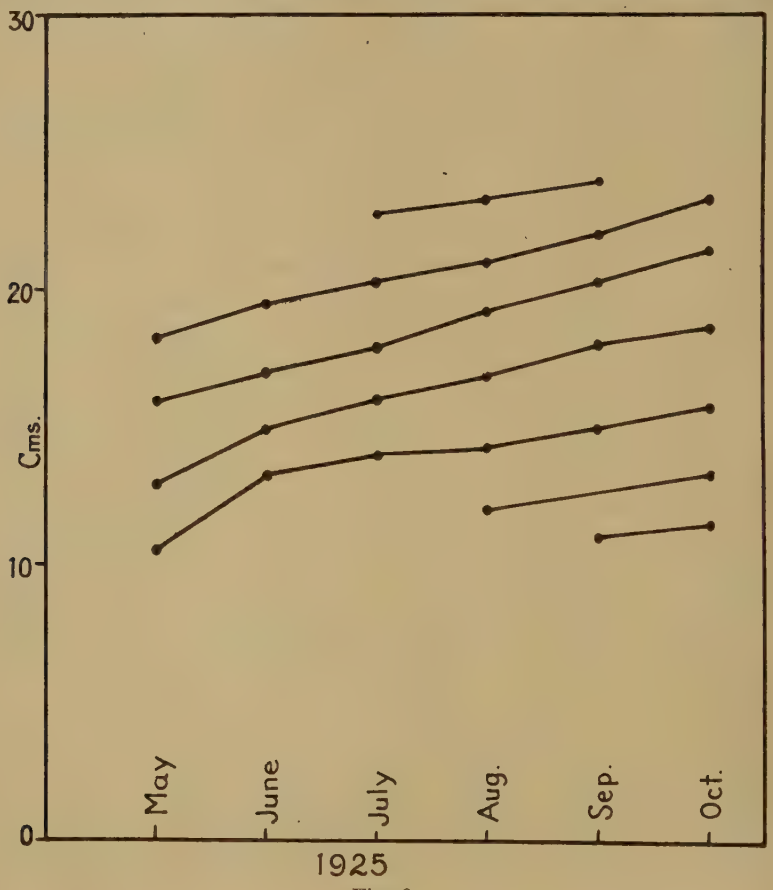


Fig. 8.

of accuracy is usually sufficient. A more accurate method is given later in this paper.

Treating the frequency groups of Figures 1, 2, 3 and 4 on the new basis, we draw freehand the compound curves shown in Figs. 4, 5 and 6. These resolve easily into the components shown. The solutions are in general unique, it not being possible to find alternative arrangements equally suitable. Instead of skew unimodal curves we have then compounds of symmetrical curves similar to the Curve of Error. Now we

must apply the test of consistency to the results. If the modes are significant and if each mode represents a sub-group of fish there should be a steady progression in the position of the modes from month to month in the summer. Also a part of a sample or of a collection of data should show the same modes as the whole. Fig. 8 shows the results of the first test of consistency.

In Fig. 8 the dots show the approximate positions of the modes in the frequency curves for each month in the summer of 1925. The dots have been joined up in what seems the most natural way. Poole is a district where there are "waves" of immigration of plaice, well known to the fishermen; it thus seems fairly certain that the four central lines represent the summer growth rate of the local plaice while the lower modes correspond to late summer immigrants of the I-group or possibly well grown specimens of the 0-group. The subject is treated in detail in my forthcoming report on the inshore fisheries in the Poole district and will not be further discussed here. The fact that it is possible to connect up the mode positions from month to month by almost parallel lines gives, however, strong support to the view that the modes are significant, and that the same sub-groups of fish are being dealt with from month to month. Now for the second test of consistency. The dotted line in Fig. 7 is drawn through the frequencies of fish of the I-group identified as such by examination of the otoliths. A certain number of fish in certain hauls as well as all the fish from certain hauls were examined in this way, hauls and fish being selected quite haphazard. It will be seen that each mode in the whole collection is represented by a mode in the small sample though the latter comprises 47 fish only. This gives very strong indication not only that the modes are significant but that the whole sample is composed of fish of the I-group. Even stronger evidence of the significance of the modes is given by dividing the total collection in a month into two and finding the modes for each half and for the whole collection. This test was applied in the collection of measurements made in July 1927. The modes are found to agree almost exactly as to their position, and their relative heights agree also. Agreement was found also in the modes in the males and females, in the same collection, taken separately. The test has not been applied in other cases, these three being deemed sufficient to prove that the modes or "roughnesses" in the original data represent actual sub-groups and should not be smoothed out.

It should be noted what very different results from those shown in Fig. 8 would be given if the mode or the mean size of the I-group were taken for the calculation of summer growth. The late immigrants

form a very large sub-group and their small size would have the effect of depressing the value of the said constants, giving an apparently backward growth in the later months.

It was earlier mentioned that a more precise method than that of freehand drawing may be applied to the resolution of compound curves into symmetrical components. It is only applicable when three outer frequency sub-groups may be regarded as belonging entirely to one component group, and when the lowest of these contains not less than 3 or 4 fish. Further, the logarithms of the three ordinates must lie on a curve concave to the axis of abscissae. If they do, a Curve of Error can be drawn through the three points and can of course be continued beyond them on either side, including the points overlapped by the next sub-groups. The curve being thus completed, each ordinate of it is subtracted in turn from the ordinate of the compound in the overlapping region, giving thus points on the next component curve. The process may be continued until the whole composite curve is resolved into component curves of error. Of course Curves of Error actually overlap to infinity, but ordinates of under unity may be neglected for our purpose. It is necessary to reject very low ordinates in choosing the three points since an error of one or two fish in these may have an undue effect on the shape of the curve. I have tested the method on several composite plaice measurement curves and have found that my freehand curves are so nearly Curves of Error that it is quite unnecessary to go to the extra trouble. The modes in the freehand curves agree almost exactly with the mathematically derived modes.

The precise method is derived from that which I have given in a paper on the Selective Action of a trawl net (Journal du Conseil Int. Vol. II. No. 3. 1927).

It is as follows:—

1) Find the logarithms of the three chosen ordinates. Call them in order from the left y_{-1}, y_0, y_1. Fit the parabola $y = a + bx + cx^2$ to these logarithms. The constants are given as follows:—

$$a = y_0$$

$$b = \frac{y_1 - y_{-1}}{2}$$

$$c = \frac{3(y_1 + y_{-1}) - 2(y_1 + y_0 + y_{-1})}{2}$$

The origin ($x = 0$) is at the central ordinate and other ordinates, y_{-2}, y_{-3}, y_2, y_3, and so on, are calculated by substituting the corresponding values for x, namely $x = -2$, $x = -3$, $x = 2$, $x = 3$, in the equation.

The position of the mode is at

$$x = \frac{-b}{2c}$$

and the height of the mode is obtained by substituting this value for x in the equation.

If it is desired to test how near a freehand curve is to the actual Curve of Error this may very quickly be done by the method of least

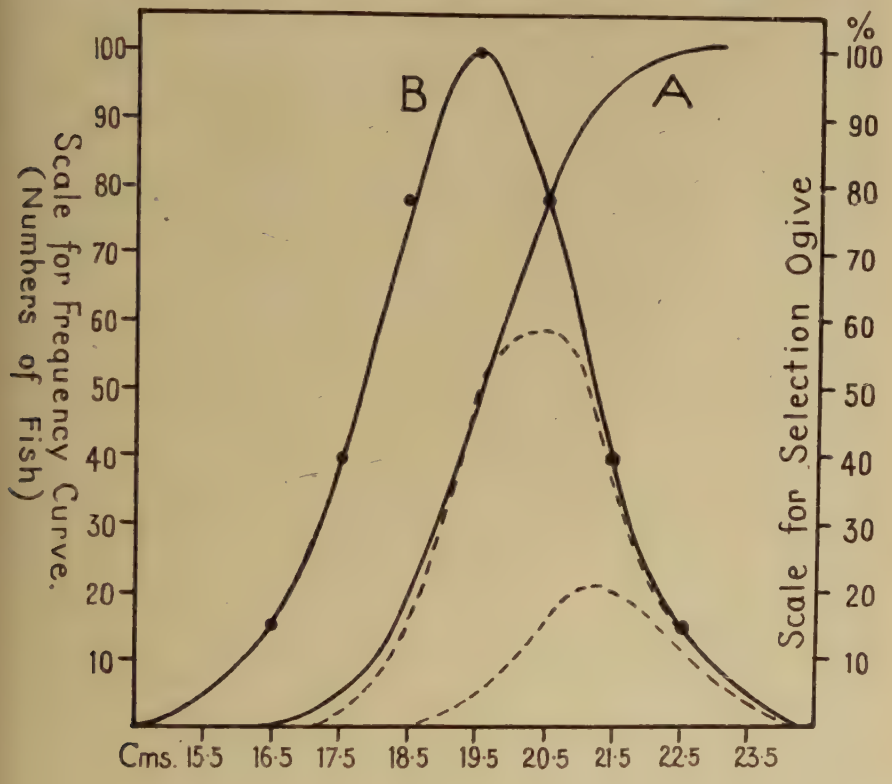


Fig. 9.

squares. If absolute standardisation of method is required this treatment commends itself. It is only necessary to take any given number of ordinates on the freehand curve and to fit a parabola to the logarithms of these ordinates. My cited paper on Selection gives details of the method. Actual Curves of Error may then be substituted for the freehand curves, and the composite curve has then been resolved into a few Curves of Error usually with very slight discrepancies. It is best not to use the ordinates of lowest value for this purpose as they have a disproportionate effect on the result. Ordinates may be taken at each centimetre or each

half centimetre or at any other equal intervals. It is unnecessary to give an example of this application of the present method, the working being precisely the same as in the example given in the cited paper, which also gives a simple method for finding the Standard Deviation of each component curve.

Before concluding this section it may be of interest to discuss shortly the effect which selection due to the mesh of the net may have in modifying the frequency distribution of fish sampled. In my cited paper a method is given for deducing the "Law of the Mesh" from data of covered net experiments. Within the range of the "law" the proportion taken, at each length, of fish sampled, appears to be independent of the number at each length. That is to say, if there are 1000 fish at 16 cms. and 2000 fish at 17 cms., and the "law" states that 20 per cent. of the fish at 16 cms., and 25 per cent. of the fish at 17 cms. ought to be taken, 200 fish of 16 cms. and 500 of 17 cms. may be expected in the sample. Thus the frequency curve representing the fish sampled may be treated with the curve of selection, whatever the size range and whatever the modal size of the sampled distribution, and the "law" will hold within its own range; except that it will not hold throughout its range on the lower side, a quite disproportionate amount of very small fish being taken. On the upper side none of the fish will go through the meshes, so the "law" may be considered as holding good on this side. Fig. 9 illustrates the application of a "selection ogive" to a hypothetical group of haddock obeying the normal Curve of Error distribution. The ogive (Curve *A*) is deduced from data dealing with covered cod-end experiments. My cited paper gives a very simple method for deducing the "mode" and "standard deviation" of a selection Curve of Error; these being found, the ogive may be plotted at once from any tables of values of the Probability Integral, for instance those given in PEARSON's Tables on page 2 et seq. The selection Curve of Error of which the ogive is given in Fig. 9 has the "mode" at approximately 19.5 cms. and a standard deviation of approximately 1.2 cms. To draw the ogive put $x = 0$ at 19.5 cms., and find the values for $x = {}^1/_2$, 1, $1{}^1/_2$, 2, $2{}^1/_2$, 3, the ordinates being plotted at 6 cms., 1.2 cms., 1.8 cms. and so on. The lower half of the ogive is the same as the upper half but measured in the opposite direction. The ogive is fixed in position for any particular mesh and species of fish but that part of any group of that fish coming within its range is affected by it. Curve *B* in Fig. 9 is a hypothetical group of haddock. First let us consider this group to have its mode at 19.5 cms., that is to say at the centre point of the ogive. The ordinates of the frequency curve (we are considering areas of the curve and "areas"

in the rough data as ordinates throughout this paper) are now multiplied by the corresponding ordinates of the selection ogive which are read as 10 per cent., 20 per cent. and so on up to 100 per cent. The resulting curve is the upper one in broken line. The area of the curve has been reduced to about half its original dimensions, but it has not been rendered very skew. Now consider the abscissae of the frequency group to be reduced by one cm. throughout and once again apply the ogive. The resulting curve is the lower one in broken line. The frequency curve has been reduced to a very small proportion of the original, the mode has been shifted $1^3/_4$ cms., and the group has been distinctly "skewed" but not to the extent which is commonly supposed to be the effect of net selection. Three interesting points arise from this experiment, a) the resulting skew curve gives the feeling of continuity when drawn and not the feeling of strain before referred to. b) If a very skew but continuous distribution is met with and there are reasons for assuming that the group of fish sampled have a symmetrical frequency distribution, the sample must be only a minute proportion of that which would be obtained by a smaller mesh. c) If the sampled population grows only one cm., double or more than double the catch per hour of them may be made, assuming the density of population unchanged. Within limitations it should be possible to build up the selected sample to a true sample of the population within a known range, and this may prove very useful for deducing the positions of modes of the groups just below those caught commercially. This may be of practical service as these groups will in the near future be of commercial importance.

The method as applied to Herring Data.

By *W. C. H.*

I propose to show in the following examples, how, by treating both measurements of fish, and calculated measurements by this method, a clearer view of the data can be obtained. It has hitherto been the practice to employ such statistical methods as finding the mean length, median length, or semi-inter-quartile range in dealing with the "spread" of length frequency groups, but unless our data are absolutely homogeneous i.e. distinctly uni-modal and more or less symmetrical, these expressions do not lead us far in the direction of obtaining a rational view of the natural phenomena which are constantly taking place among the herring shoals.

For instance, the spawning of the herring of the British waters takes place practically all the year round, with the result that we must, of

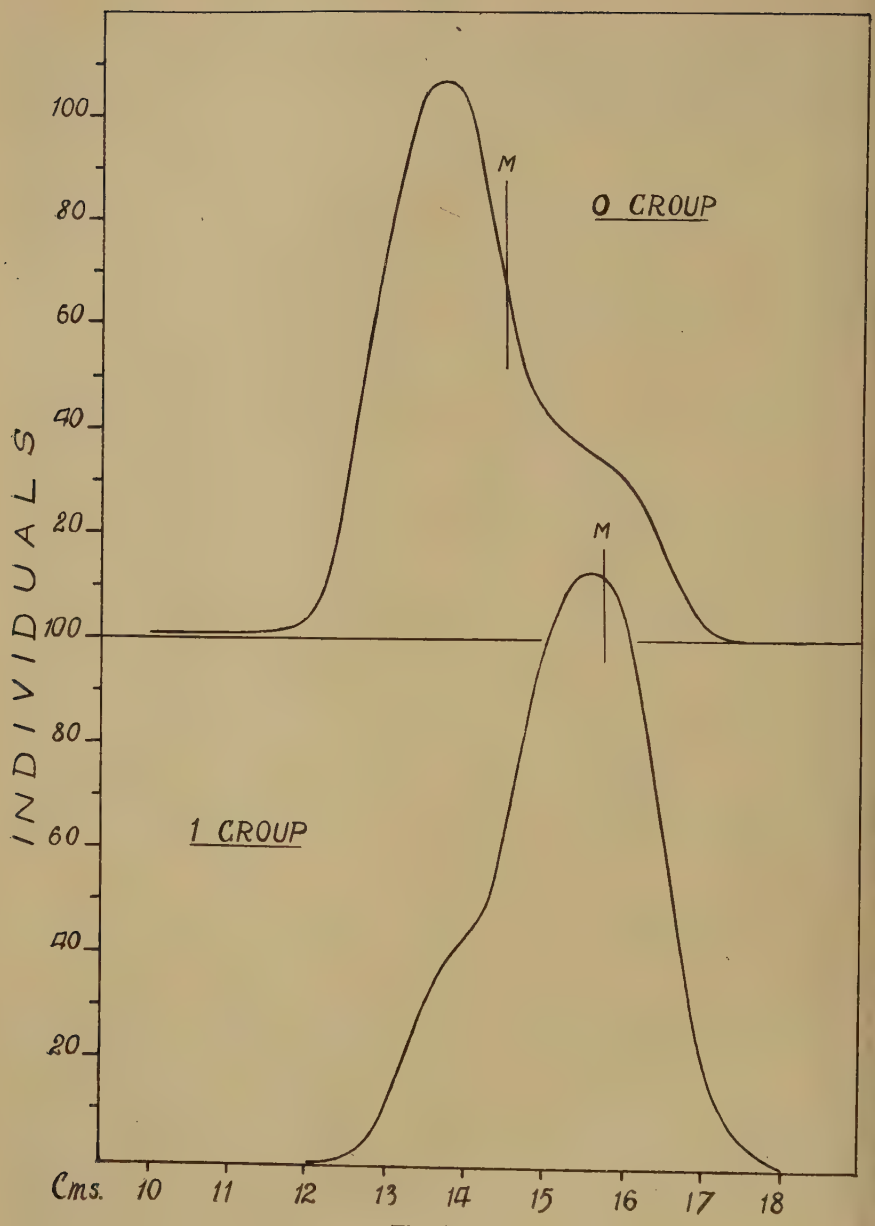


Fig. 10.

necessity, find ourselves dealing with shoals made up of innumerable broods of fish which are derived from these spawnings. Let us assume three broods of young herrings, *A*, *B*, and *C*, to be the components of a shoal. Now we may have many of *A*, and few of *B* and *C*, or few of *A* and many of *B* and *C*, and so on.

The mean length of the first collection would be nearer *A* than *B* and *C*; in the second nearer *B* and *C* than *A*. The means may point to statistically different shoals, while actually they are biologically similar. Our aim, then, is to divide our material into biological groups before comparisons are made.

The examples given are taken from data examined by other workers. The material collected by the Ministry of Agriculture and Fisheries will be given in a report at present in preparation.

The first illustration is taken from material examined by SAVAGE in 1913—14[1]).

By means of scale readings, a sample of young herrings from Aldeburgh, caught in February 1914, was divided into 0- and I-group fish. The lengths of the two groups have been plotted in Fig. 10.

By treating the data as though they were made up of symmetrical groups instead of forming "skew" curves, we find that both sets of measurements form bimodal curves, the two modes of the lower curve falling immediately beneath the two modes of the upper curve. The significance of this is, that the 0-group as defined by the scales includes some of the I-group fish, and the I-group includes some of the 0-group. Faulty scales would account for this. The two lines marked *M* show the position of the means. The mean in the 0-group curve has no significance at all from a biological point of view, but the modes tell us that we are dealing with two lots of herrings whose length varies symmetrically about the lengths 13.7 cms. and 15.5 cms. Further investigation has shown that these two groups of herrings are very common. We also know that there is no biological connection between the 0- and I-groups as shown above, i.e. they are derived from different spawnings. This occurrence in the sample is due to the mixing of the shoals.

The second illustration is taken from FORD's "Herring Investigations at Plymouth" 1928[2]).

In Part IV, Table III (p. 317), he gives measurements of young herrings caught at various dates in the Rivers Tamar and Tavy. Owing to a deformity in the tail of many of the herrings he has separated them into normal and abnormal specimens. It is the normal fish only with which I propose to deal.

In Fig. 11 I have drawn the groups of young herrings taken from June 23rd to October 7th.

It is at once evident from the diagram that the material is not homogeneous. There are several broods of young herrings in the catches,

[1]) R. E. SAVAGE. Fish. Invest. Series II. Vol. IV. No. 1. 1919.

[2]) E. FORD. J. M. B. A., N. S. Vol. XV. No. 1. 1928.

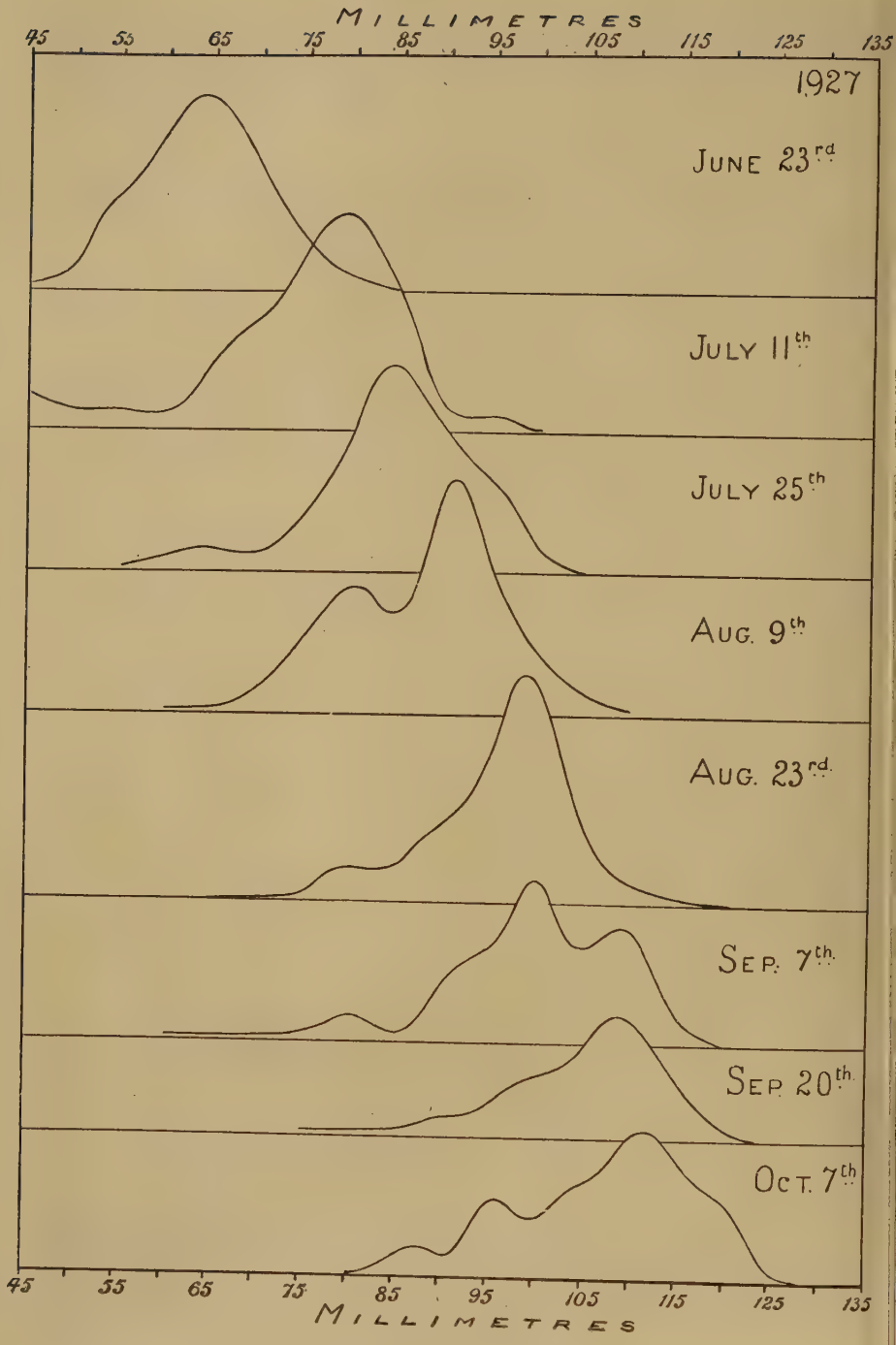

MILLIMETRES
45
55
65
75
85
95
105
115
125
135
1927
JUNE 23rd
JULY 11th
JULY 25th
AUG. 9th
AUG. 23rd.
SEP. 7th.
SEP. 20th.
OCT. 7th.
45
55
65
75
85
95
105
115
125
135
MILLIMETRES

Fig. 11.

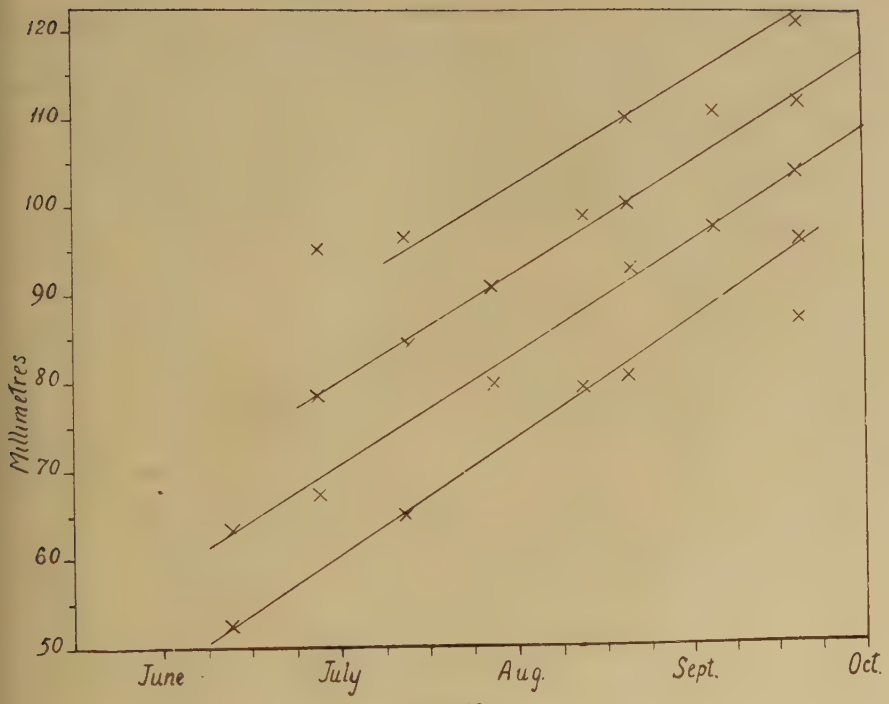

120
110
100
90
80
70
60
50
Millimetres
June
July
Aug.
Sept.
Oct.

Fig. 12.

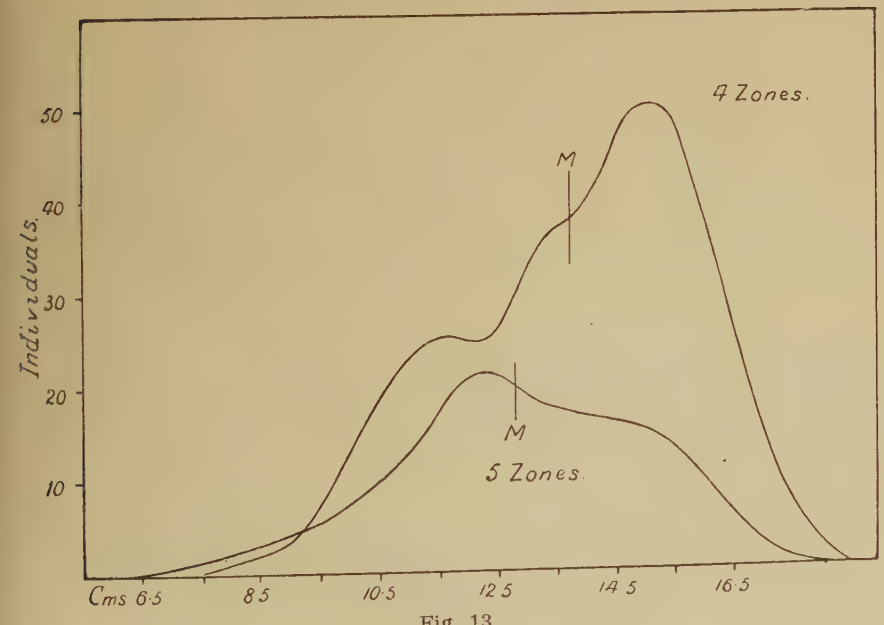

50
40
30
20
10
Individuals.
4 Zones.
M
M
5 Zones.
Cms 6·5
8·5
10·5
12·5
14·5
16·5

Fig. 13.

and these broods vary in proportion from time to time, but in general, the modes move gradually to the right as the time of sampling advances.

In the next diagram (Fig. 12) all the modes have been copied and put into their correct position with respect to time.

It is now found that the various modes lie on or very near to, four

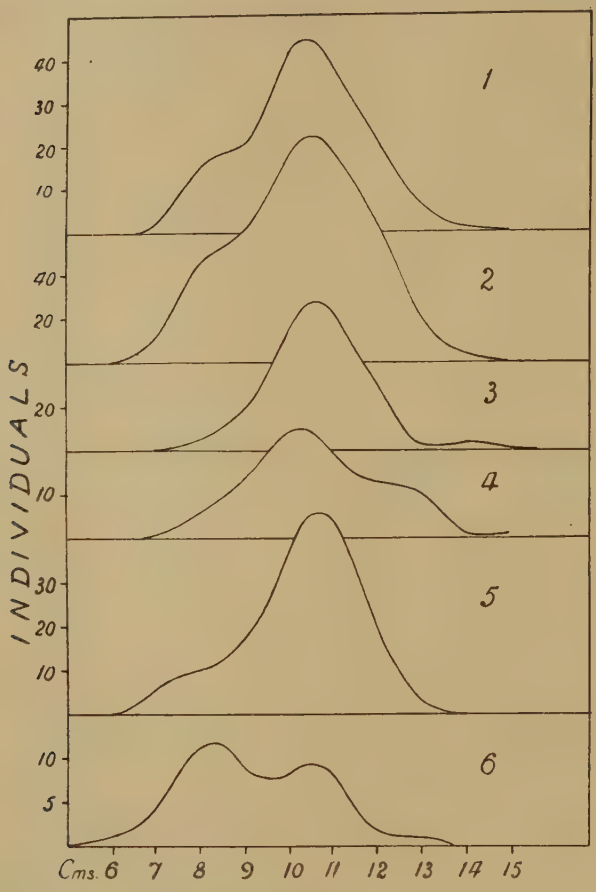


Fig. 14.

parallel lines, thus it is more rational to assume that the measurements relate to four broods of young herrings, each having the same growth rate, than to one brood.

Fig. 13 represents two collections of growth calculations (length l_1) taken from the same paper by Ford (pp. 294, 295). The upper curve is drawn from calculations made on 4-zoned fish in 1924—25, and the lower curve represents the length l_1 for 5-zoned fish caught in the same season.

The former group exhibits three modes at approximately 11.5 cms., 13.5 cms., and 15 cms. The second group certainly contains two modes at 12 cms., and about 15 cms. The flat surface between these two modes suggests the presence of a third, which, owing to the manner in which the curves for each brood are added, is probably concealed.

The difference between the smaller modes is about .5 cms., which is small, especially as we are dealing with different year-classes, and the larger modes are almost identical.

The lines *M*, show the positions of the means, which again do not mean anything biologically. I consider these two curves to show that the two year-classes mentioned were derived from spawnings at the same time of year in each case, the only difference being that the components appear in different proportions.

Finally, in Fig. 14 are six curves representing some growth calculations made by STORROW[1]).

The samples all show the length of herrings up to their first winter-ring, and are:—

1)	3 winter-ringed fish — Firth of Forth.....	February 10th, 1921
2)	5 — — — — Firth of Clyde.....	1922
3)	1918 year-class — Lerwick	March 9th, 1923
4)	— — — Wick.....	January 24th, 1923
5)	— — — Eyemouth	February 8th, 1923
6)	— — — Yarmouth	November 15th, 1922

All of these samples show two modes at least, and these are all directly under one another. The mode at 10—11 cm. is present in abundance in all the Scottish samples, and the mode about 8 cms. is less pronounced.

As will be shown in a later report, the 10—11 cm. mode, emphasises the importance of the Autumn spawning to the fisheries of the North Sea. The last sample (6) although it contains only 44 fish, still shows the same two groups.

These few samples, and the others in a forthcoming publication will serve to show that this method of treating ichthyometric records, for herring at any rate, is likely to help in the formation of new ideas regarding the composition and origin of the shoals in all waters.

---

[1]) B. STORROW. Dove Mar. Rep. N. S. XII. 1923.

Correspondence.

(1).

In a review by T. Edser, in the Journal du Conseil, Volume IV, No. 1, p. 118, of two papers from the California State Fisheries Laboratory, Fish Bulletins Nos. 12 and 13, by Dr. Clark and Mr. Andrews, it is apparent that certain comments have been made which might have been different had the reviewer known more of the program of which these are a part. The writer, although not now responsible for the work at that laboratory, is familiar with certain of its original aims, and therefore ventures this comment.

Both papers are a part of an attempt by the laboratory to follow from year to year the dominant year or size classes in the sardine, their effect upon the seasonal fishery, and their times of occurrence in the commercial catch. It is sought to connect actual variations in the occurrence of smaller sizes with resultant variations among the larger sizes in later years. This is entirely aside from use of the doubtful age readings, for at present these can be at best but a series of more or less skillfully made arbitrary decisions. The laboratory has proceeded on the assumption that variations in age composition if enough to be significant to the industry, are reflected in size composition[1]). The use of sizes instead of age readings renders possible the use of great numbers, collected at all times of the year. It leads to a better conception of the seasonal variability in the catch.

Mr. Andrew's work, an analysis of this seasonal variability, has especial significance, in that it shows that sampling, either for age or for size, must be made with careful attention to the seasonal "run". His results show that careless sampling at various seasons cannot reflect

[1]) This is obviously true of the smaller fish, whose age groups are well separated in size. An adequate number of samples and individuals for the determination of the relative number and the average size of each age group of these smaller sizes would seem especially desirable. It is difficult to see why there should not exist nearly as great a necessity for accuracy where the age groups overlap in size.

anything other than the variations in sizes caused by the change in time of sampling. It may not be out of place to say that in no investigation I am acquainted with has there been as thorough a study of the basis of sampling.

The significance of Dr. CLARK's paper is not properly brought out in the review. In any study of the relative abundance of age classes, of their growth, or in any study of migrations or spawning habits, it is of great importance that some method be available whereby the condition of large numbers of fish at any one time can be ascertained readily. It is also desirable that some idea of the variability from time to time, or as between sizes, be obtained, especially in a species such as the sardine, which may conceivably be dependent upon, and its abundance be correlated with, plankton and its distribution. Furthermore, from an economic standpoint, the condition of fish from year to year, or from season to season, is of great interest to the manufacturers of fish meal and oil.

Measuring to the nearest millimeter, which is said to be "an unnecessary refinement", is justified on the following grounds: (1) In the investigations, of which the articles under discussion are a part, all sizes of fish, from the very smallest to 28 cm. are used. It would be exceedingly unfortunate to use different methods for different lengths of fish. (2) Measurements are made of both total and body lengths, which in each individual case are checked against each other by means of a comparison of the actual observed difference with the expected difference between these two lengths, as determined by a large series of measurements. This would be impossible without the accuracy used. (3) In the field measurements by assistants of various degrees of skill and carefulness, it has been found through actual experience, in California, that by requiring each measurement to be made exactly and with the care necessary to read to millimeters, the personal error is radically reduced and accuracy is notably greater, particularly when checked by comparison of two slightly different measurements as discussed above. (4) In studying the seasonal changes in modal or average lengths of size groups or age classes, by means of many thousands of individuals, an annual change of less than a centimeter is mathematically and biologically significant. It is a debatable question whether the act of throwing measurements to a nearest whole or half centimeter could not under certain circumstances (such as altered symmetry of distribution) obscure the differences in position of a mode or even an average. The sardine grows about a centimeter a year or less, at 21 cm. (See Figure XI of Miss CLARK's paper, showing deviations of length frequencies.)

In Mr. ANDREW's case, the smoothing of the data to secure trends by a moving average of 29 days is criticized, and it is suggested that fortnightly means be used. Since the purpose of the smoothing was to eliminate minor fluctuations of the character of lunar (monthly) cycles which are known to exist in the sardine, the use of fortnightly means would be mathematically erroneous. The method of smoothing by moving average is a standard one, commonly in use, and the number of items in the average is indicated by the length of the fluctuation to be eliminated. The criticism would appear to assume an ignorance on the part of Mr. ANDREWS which did not exist—although for the sake of his readers he might have advantageously smoothed the resultant trends manually.

Finally Dr. CLARK discusses at some length her use of the cube of the length rather than the value 3.15. The reader might be referred to her discussion of this. The latter use would have involved very considerably more work, with no corresponding advantage in handling great numbers of measurements. Dr. CLARK did not depend upon what is shown in her second figure for a justification of her choice.

It might be added, that the values in formula Weight $= FL^X$, are shown to vary considerably from year to year, and the assumption that the values given are correct under any conditions would be a mistake. But knowing that the error which arises by the use of the cube of the length does not invalidate the conclusions sought, there seems no logical reason why, although slightly less precise, it cannot be used because of its greater convenience. A casual inspection of the variability of the "condition factor" as shown by Dr. CLARK's figures V to X should convince one of the justice of her reasoning that the error involved is an inconsiderable one.

W. F. THOMPSON,
Seattle, Washington, U. S. A.

---

(2).

The objects detailed above are common to many of the programs undertaken by fishery investigators and are so well known to all researchers that recapitulation even if permissible is unnecessary. The methods employed to elucidate the problems, more particularly the statistical techniques, have not yet been standardised, and it was mainly to this end that the remarks in the review were directed.

Measuring to the nearest m. m. is, in my opinion, impossible with a fish of the length quoted. The difficulties of handling its curved flaccid body preclude such a degree of accuracy. Further I fail to see how com-

parison of the difference between total and body length with a predetermined fixed difference can lead to such precision. If the differences differ, how can they be reconciled?

The reason now given for Mr. ANDREWS choice of a 29 days smoothing period puts this matter in a different light, but a reference to the reason in the paper itself would have been helpful.

Finally the justification of an admittedly inferior cubic equation on the score of the extra work involved by substituting the factor $L^{3.15}$ is not convincing: the preparation of a Table for $L^{3.15}$ would not be a very stupendous undertaking. T. E.

Reviews.

Verhandlungen der Ozeanographischen Konferenz anlässlich der Hundertjahrfeier der Gesellschaft für Erdkunde zu Berlin, 24—26 Mai, 1928. — Ergänzungsheft III z. Zeitschrift der Gesellschaft f. Erdkunde z. Berlin — pp. XIV + 156 with 86 text figures and 3 tables. Berlin. 1928.

The Gesellschaft für Erdkunde zu Berlin celebrated its centenary on the dates May 24th—26th, 1928, and the volume under notice constitutes a special supplementary number of the Society's Journal devoted to the papers read at the two day oceanographical conference which fitly marked the occasion. Naturally from the German side, the methods and results of the Meteor Expedition constituted the chief theme, and Dr. Böhnecke had arranged an exhibition of oceanographical instruments. The organisation of the conference was in the hands of a "Presidency" comprising Staatsminister Dr. Schmidt-Ott (President), Admiral Zenker, Staatssekretär Dr. Heinrici, Vize-Admiral Dominik, Professor Dr. Defant (organising Secretary), Professor Dr. E. v. Drygalski, and Professor Dr. A. Penck (President of the Gesellschaft).

In his foreword to the volume, the Editor records that the chief motive in inviting the various lecturers, was the desire to provide a medium for authoritative accounts of expeditions recently carried out, or shortly to be carried out. Apparently lateness of receipt prevented the publication of two papers sent in. The publication of the volume was rendered possible by a considerable subvention from the Notgemeinschaft der Deutschen Wissenschaft. There is printed an opening address given by Dr. Schmidt-Ott; in it he referred to the achievements of the great ocean research expeditions of the past, both German and non-German, and said that such work always aroused general interest no matter by what nation it is carried out. He touched upon the pleasant associations which his official duties had given him with preparations for such marine research expeditions as concerned the Reich. The Meteor Expedition he said, had had the inestimable boon of co-operative assistance from the Notgemeinschaft der D. W. and the German Navy. They had placed the Meteor Expedition in the forefront at the conference with the result that other expeditions perhaps "took a back seat", but they trusted that this would not be taken as a sign that they over-valued their own work. The position of precedence was a grossly inadequate recognition of the courage, endurance, and complete devotion to duty of the scientists,

ships' officers and men. What particularly distinguished the Meteor Expedition was the scheme of operations drawn up by their never to be forgotten friend Alfred Merz. By the exercise of admirable care and forethought, Merz had been able to include in the scheme of work, an abundance of apparently irreconcilable activities. The speaker had, when he met the Meteor at Tenerife on her home-coming, been astounded to note with what precision Merz had foreseen even what bulk of records would be amassed. The systematic accomplishment of the entire project surely offered a specially valuable stimulus to future ocean research voyages and, in consequence, they had made very special efforts to accelerate the publication of the results accomplished; all would be published within five years.

Before an audience including some 130 delegates from geographical and allied societies all over the World, Professor A. Defant gave an address upon "Die Systematische Erforschung des Weltmeeres". This paper is not printed in the book under review as it had already appeared in a special jubilee volume of the Society's journal along with a very important paper by Wüst upon "Der Ursprung der Atlantischen Tiefenwässer". Professor Defant said that Merz's Meteor Expedition had as its prime task, the prosecution of a systematic physico-chemical exploration of a large ocean area and the production thereby of a large mass of material which marine research in all oceans needed to-day for its further development. This expedition typified the change over from the more qualitative grasp of oceanographical facts. The speaker showed how meagre were the hitherto available data which could usefully serve to elucidate the deep water circulation of the oceans; — in the Indian Ocean only two and in the Pacific Ocean only sixteen stations had been worked at over 3000 metres. In the Atlantic, prior to the Meteor Expedition, the available data merely sufficed to permit one to draw a far from reliable section along 30° W. The southern Atlantic is known now thanks to the Meteor Expedition, but there remain many ocean areas hardly explored yet. Professor Defant sets up some very interesting analogies between the physics of the atmosphere and the hydrosphere; we read of marine analogies of troposphere, of stratosphere, of centres of action, and of polar fronts. These analogies are far reaching but are of enantiomorphic application. The warm troposphere extends down to some 1300 metres and under it occurs the oceanic stratosphere whose waters are homothermal having weak currents only — due to local salinity differences. The disturbance zone is the upper 200 metres layer of the troposphere. Under the hypothesis of an enclosed hydrosphere, theoretical ideas as to the position of the junction surfaces between tropo and strato-spheres are worked out. A further step is the deduction of ocean currents and it is found that deduction and practical knowledge accord remarkably well. The currents of the troposphere are in the main conditioned by the effects of radiation and wind on the uppermost layers within the oceanic polar fronts; those of the stratosphere on the other hand result from precipitation, ice melting, and radiation to the sea surface polewards of the polar front.

Professor Haber of Berlin gave a paper on "Das Gold im Meere". Estimations existed pointing to a gold content in sea water ranging from

3 to 60 mg. per tonne and the speaker had wondered whether extraction on a paying commercial scale were not possible. The analysis made use of depends upon the production of a metallic bead by the ignition of a precipitate of lead sulphide in which the gold was thrown down. From 186 Meteor stations spaced over ten lines of stations, about 1400 sea water samples were analysed satisfactorily and the gold content, expressed as a grand mean worked out at 0.004 mg. per tonne — a result about $\frac{1}{1500}$ of that previously accepted. Professor Haber finds it perfectly impracticable to make paying commercial extraction. A very important result is his proof that gold is present in suspension — a fact known earlier but now more certainly established for a wide area. The surface waters are richer in gold than are the waters of the depths, and Professor Haber finds reason to explain the variation in gold content at different depths and in different areas as due to actual gold transporting powers of the various members of the plankton.

Professor Bjørn Helland-Hansen spoke on "Meeresforschung mit kleinen Forschungsschiffen". His chief theme was the great value of small research vessels in enabling one to fill in the details of oceanographical pictures only roughly blocked out by the necessary initial big ship expeditions. We are given an impressive account of the work done from small Norwegian research vessels, and are reminded that in many areas a very closely spaced widely spread net of stations must be worked since often great differences are observable at short distance intervals. Small vessels are much more economical to run and many small ship expeditions are immeasurably preferable to a few large ship expeditions. Nowadays theory tends to lead practice in oceanography, thanks to such mathematical processes as those available for the deduction of convection currents. Details of the 57 ton "Armauer Hansen" and an account of some of her achievements are given. Particularly interesting is Professor Helland-Hansen's showing that apparent submarine seiches may sometimes be due to the lateral movement of sloped discontinuity surfaces.

Professor Johan Hjort next spoke on "Die Pläne der Internationalen Meeresforschung". After insisting upon the debt which modern oceanography owes to the venturesome sea-captains and whale-fishers of old, he led up to the initiation of modern quantitative marine research with its investigation of the inter-dependence of plankton and manurial substances. A specially interesting point is his query as to whether the great equatorwards going movement of polar water at depths of 500—1000 metres (as now demonstrated by the Meteor results) does not explain the previously known presence there of the sperm whale's food — via the fundamental plankton link provided by a rich plankton content of this polar water. Professor Hjort gave a brief review of some of the fishery research work done by the Council's adhering countries.

The next speaker was Director Van Riel who gave an account of "Die geplante niederländische Expedition in die Meere des ostindischen Archipels". A review of the meagre available oceanographic data is given and it is stated that geology, physics and chemistry will figure chiefly in the work to be done. One important task is to assess the water exchange between the two oceans via the Straits of the Archipelago. Details of the

1050 tons research vessel "Willebrord Snellius" are given. The expedition will last about 15 months in all. The vessel is fitted with two types of echosounder.

A paper by Messrs. J. A. Fleming and J. P. Ault follows, entitled "Program of scientific work on Cruise VII of the Carnegie – 1928-1931". The present cruise will add some 110,000 miles to the handsome total of 290,000 miles already covered in all oceans. Thanks to improvements in instruments which have cut out the necessity of carrying duplicates and of duplicating many routine observations, it has been possible to include a programme of oceanographical work. The work done aboard this specially designed "non-magnetic" yacht, makes very interesting reading indeed. She is a veritable mass of instruments and all of these seem to have been brought after long use and experiment, to a high pitch of perfection. Little save trawling seems to be left out of the ambitious scheme of work.

The next paper is of very special interest and would merit a very full review were such possible. It is by Dr. Georg Wüst and is entitled "Ozeanographische Methoden und Instrumente der D.A.E."[1]). Dr. Wüst's actual discourse is not all contained in the paper before us. The progress of ocean research is, we read, necessarily bound up with the development of more searching methods and of much improved instruments. Merz drew up the D.A.E. working plan with this conviction. The D.A.E. marks a break with the time honoured practice of piecemeal working; for such is substituted a systematic survey of an entire ocean. The oceanographical programme was the chief concern of the expedition and its chief goal the elucidation of the deep water circulation *via* temperature and salinity studies. Some 9,000 observations of both salinity and temperature were made from the 310 stations worked; some salinity samples were analysed six times. We are given an impressive account of almost incredibly accurate apparatus, of thermometers correct to $\pm 0.005°$ C. and of salinities determined to $\pm 0.004\ ‰$ chlorine. By means of the highly successful employment of special thermometers responding to pressure change, the actual depth from which samples were taken is correct to within 10 metres. Direct current measurements down to 2500 metres were made at anchor stations by means of Ekman's repeating current meter and the new Merz-Ekman deep sea current meter. The main findings as regards the deep water circulation were given.

Professor Hentschel of Hamburg reports upon "Die biologischen Arbeiten der D.A.E." and his paper is a record of almost herculean labours. Some 1245 centrifuged samples of micro-plankton were quantitatively analysed aboard; micro-plankton from all depth horizons was studied. Recognisable connections between plankton, currents and phosphates are noted. Areas of upwelling (e.g. of Cape Blanco) have a profuse plankton population.

Dr. Wattenberg's paper on "Die chemischen Arbeiten der D.A.E." follows. Amongst a wealth of interesting things we learn of a connection found between CO_2 tension and chalk content in the water samples.

---

[1]) "D.A.E." is used herein as an abbreviation for Deutsche Atlantische Expedition.

Dr. SCHUMACHER writes on "Die stereophotogrammetrischen Wellenaufnahmen der D.A.E.". Particularly interesting is the statement that the accuracy of the instruments was tested out by photographing Saint Paul's Rocks. It seems that 9 metres was the height of the highest wave measured.

Professor CORRENS writes on "Mineralogisch-geologische Arbeiten der D.A.E.". A remarkably fine scheme of work was carried out; the use of artificial matrices of canada balsam enabled microscopical examinations of ooze sections to be made. Elutrication treatment was given to samples. One finding was that the Congo-Cape basins have lime rich sediments and the Brazilian basin clayey deposits.

Professor Dr. H. MAURER writes on the Meteor's echo sounding work. An area 90 times as big as Germany was covered with soundings; 67,400 soundings were made, an achievement which, by the use of wire soundings would have occupied some 7 years.

Kapitän SPIESS writes about the ship herself and the nautical work and his account is really extraordinarily interesting. We read a striking tale of difficulties due to inadequate propulsion power and of stringent watch upon steam consumption necessitated by exigencies of coal supply. The account of the deep sea anchoring gear is very instructive.

This volume is of very great value indeed as a handy epitome of the work done on the D.A.E. Such notice as it has been possible to give of the many excellent and important papers is almost uselessly "scrappy" but an English summary of the volume has been prepared by the reviewer and could be consulted by anyone interested.

J. N. CARRUTHERS.

J. N. CARRUTHERS. The Flow of Water through the Straits of Dover as gauged by continuous current meter observations at the Varne Lightvessel (50°56′ N. 1°17′ E.). Part I. Methods employed, with a Preliminary Survey of the Results. — Ministry of Agriculture and Fisheries. Fishery Investigations. Series II. Vol. XI. No. 1. London 1928. 108 pp. 34 charts.

Die Reststromuntersuchungen des Verfassers im Kanal und in der südwestlichen Nordsee, die mit einem für kein Meeresgebiet in nur annähernd ähnlich reichem Umfange vorhandenen Beobachtungsmaterial an Flaschenposten erfolgreich durchgeführt sind, erfahren nun eine wichtige Ergänzung durch Beobachtungen mit dem vom Verfasser obiger Veröffentlichung konstruierten Reststrommesser, über den in dieser Zeitschrift bereits ausführlich berichtet ist.[1]) Das Instrument hat, wie die Erfahrungen bewiesen haben, drei grosse Vorzüge; es ist robust genug, um von der Feuerschiffsbesatzung bedient zu werden, auch kann es längere Zeit ($^1/_2$—1 Jahr) benutzt werden, ohne dass es reparaturbedürftig wird, und endlich ist der Strommesser auch bei stürmischem Wetter gebrauchsfähig, es ist nicht erforderlich, ihn dann einzuholen.

[1]) J. N. CARRUTHERS. A new current measuring instrument for the Purpose of Fishery Research. — Journal du Conseil, Vol. I. 1926, pp. 127—139.

Von Juni 1926 an wird mit diesem Strommesser vom Varne-Feuerschiff aus der Strom in 6 Faden Tiefe festgestellt und es liegt nun bereits eine lange Reihe von lückenlosen Beobachtungen vor. Die Ergebnisse für die Zeit vom 24. Juni 1926 bis zum 8. Januar 1928 sind in einer Tabelle mitgeteilt. Da die Beobachtungen noch ständig weitergehen, werden wir über den Wasseraustausch zwischen dem Kanal und der Nordsee noch weitere, sehr eingehende Aufklärung erwarten können, zumal ausserdem auf demselben Feuerschiff schon in den Jahren 1911, 1912, 1913 je 14 Tage und vom 1. Januar 1922 ab volle drei Jahre in $2^1/_2$, 5, 10, 15 m Tiefe u. s. w. bis zum Boden mit dem Jacobsen Strommesser Beobachtungen gewonnen worden sind, die vom »Tidal Institute« bearbeitet werden.

In der vorliegenden Veröffentlichung, die als erste von mehreren Arbeiten über mit »Carruthers Drift Indicator« gewonnenen Beobachtungen aufzufassen ist, werden in erster Linie ausführliche Mitteilungen und viele praktische Winke über die Handhabung des Instrumentes gegeben, die ohne Zweifel von allen, die selbst mit dem Strommesser arbeiten wollen, dankbar begrüsst werden; u. a. ist die den Beobachtern mitgegebene Gebrauchsanweisung vollständig mitgeteilt. Das umfangreiche Material hat bislang nur eine vorläufige Bearbeitung erfahren, indem zunächst die Extrem- und Mittelwerte näher diskutiert worden sind. Der stärkste Reststrom in die Nordsee hinein wurde vom 19.—22. November 1926 mit 16,8 sm/Tag festgestellt und der stärkste Reststrom kanalwärts Ende Dezember 1927 mit 11,9 sm/Tag. Im ersteren Falle herrschten über der ganzen Nordsee und dem Kanal stürmische nördliche und nordöstliche Winde, im zweiten Falle stand sowohl der Kanal wie die Nordsee unter dem Einfluss starker und stürmischer südwestlicher Winde.

Auch Querströmungen kamen vor, die Extreme traten ein im August 1926 mit 4,5 sm/Tag nach N. 38° W. und im Februar 1927 mit 6,1 sm/Tag nach S. 81° E. Weiterhin sind die Restströme bei den höchsten Spring- und niedrigsten Nipptiden untersucht worden, dann der stärkste und schwächste nordseewärts gerichtete Strom zur Nipp- bezw. Springtide.

Von besonderer Wichtigkeit ist die Feststellung des mittleren Reststromes in den einzelnen Monaten, Jahreszeiten und für ein ganzes Jahr Juni 1926 bis Juni 1927. Für den letzteren Zeitraum ergab sich ein mittlerer Reststrom vom 2,7 sm/Tag nach N. 53° E. Die Geschwindigkeit dieser mittleren Wasserversetzung in die Nordsee hinein stimmt erstaunlich gut mit dem von Gehrke auf Grund theoretischer Überlegungen errechneten Werte von 3 sm/Tag überein, und man kann dem Verfasser in der Anerkennung der Leistung von Gehrke nur rückhaltlos zustimmen. Als Wert für die gesamte aus dem Kanal in die Nordsee gelangende Wassermasse berechnet der Verfasser 2200 km³ (einen nur um 8 % grösseren Wert als Gehrke), sodass im Laufe von 20 Jahren eine dem gesamten Nordseevolumen entsprechende Wassermenge durch die Strasse von Dover in die Nordsee gelangt, während durch den Nordeingang zur Nordsee nach den Untersuchungen von Knudsen die gleiche Wassermasse der Nordsee schon in 2 Jahren zugeführt wird. Die durch die beiden atlantischen Pforten der Nordsee in diese hineingelangenden Wassermassen verhalten sich also wie 1:10.

Obgleich die endgültige Bearbeitung der Beobachtungen noch nicht

abgeschlossen ist, lässt sich aus den bisherigen Ergebnissen doch schon erkennen, dass die Reststrommessungen in der Strasse von Dover ausser ihrem fischereibiologischem Werte auch eine erhebliche allgemein hydrographische Bedeutung haben und es ist nur zu wünschen, dass die Beobachtungen noch weiterhin fortgesetzt werden und wir ausserdem bald die in Aussicht gestellte eingehendere Bearbeitung erhalten.

Bruno Schulz.

1) C. F. Brooks. Reliability of Different Methods of taking Sea Surface Temperatures. — Journ. Wash. Acad. Sci. Vol. 18, No. 20, Baltimore, Md., 1928, pp. 525—545.
2) G. F. McEwen. Significance of Water Temperature Measurements not made exactly at the Surface. Ibid. pp. 545—546.
3) P. M. van Riel. The Influence of Sea Disturbance on Surface Temperature. — Konink. Nederland. Met. Inst. 102. Meded. en Verhand. 30. Amsterdam 1928.

The usual procedure in commercial ships for observing the temperature of the sea surface is a legacy which has been handed down a long while without essential change. Samples of sea water have customarily been taken with a bucket either of iron or, more frequently, of canvas. Recently the methods in use have been scrutinised and revisions suggested. This attention is timely not only by reason of the change which conditions at sea have undergone, but also owing to the need for greater accuracy in the basic material for present-day investigations.

An important matter which studies such as those under review help to clear up is the precise significance of "surface" observations. The term "surface" in this connection is admittedly vague and the representative value of such observations largely depends upon the degree of homogeneity in the water column. When in very calm weather the gradient in the uppermost metre is strongly accentuated and appreciable differences may exist from centimetre to centimetre (c. f. A. Merz, Veröff. d. Inst. f. Meeresk. N. F., Reihe A. Heft 5. 1920) the actual depth to which a "surface" sample (taken from a moving ship) relates must be problematical. Since it is not as a rule practicable to obtain a complete picture of the temperature conditions in the water column (we have to be content with one observation at each point on the route), the following two questions must be answered to our own satisfaction at least. Firstly, which depth has the greatest value for the work in hand; secondly, to what extent are the observations mutually comparable, a matter which to some extent turns upon the method of observation adopted. Mr. van Riel accepts existing methods and endeavours to decide the degree of comparability among the observations obtained, whereas Dr. Brooks prefers to attack the problem through the methods and so to standardise the measurements.

As for the first question, it is sometimes held that the surface film is of the greatest importance, since it is this layer which is in direct contact with the air and in which the phenomena of evaporation, radiation and absorption proceed most actively. On the other hand, it is the condition

of the wind-stirred stratum below upon which rests, as Dr. Brooks points out, "the continuation of the influence of this sea-surface at approximately the same level of temperature". Fortunately, however, we are relieved of part of the responsibility for choice of depth, since the calm conditions necessary to the existence of a surface film and the concomitant sharp temperature gradient are not, generally speaking, the most frequent at sea, a fact to which both Dr. Brooks and Mr. van Riel refer.

In his paper, Dr. Brooks recapitulates the results of earlier studies made during a cruise in the "Empress of Britain" (Monthly Weather Review, Vol. 54, 1926), and these conclusions are supported by means of additional information gathered on a later cruise in the "Finland". The suitability of the condenser-inlet for surface temperature observation is maintained and experience of the operation of thermographs already installed in various ships leads Dr. Brooks to recommend these instruments for the purpose of measurement. Except in calm weather and near the shore, 98 per cent. of the surface observations (i.e., made with a bucket) were the same as those at 5 to 7 metres. In calm weather, however, a difference of about 1° C. was noticed between observations from over the bow and in the stern-wash and there was also an appreciable difference in temperature of the sample according to the distance from the ship's side at which the bucket was dropped in the sea. Nevertheless, it appears that even in summer canvas bucket observations are less reliable as measurements of the temperature of the actual surface than are condenser inlet observations, owing to cooling of the bucket by evaporation.

Dr. Brooks adds a further source of error, namely, guesswork, to his previous list; that is to say, occasionally the temperature was simply guessed to save the trouble of drawing a sample.

The gist of the short note by Dr. McEwen is to the effect that it should be possible to draw up and apply suitable corrections to observations at 5 metres which would render them comparable with "surface" observations. It is also shewn that about sixteen observations were required to estimate with a probable error of 0.2° C. the average temperature of a certain area of sea surface off California over a period of ten days.

The main conclusion reached by Mr. van Riel is that, where temperature decreases as depth increases, the effect of sea-disturbance is to reduce the average surface temperature. It is also shewn that where temperature increases as depth increases, this effect is reversed. Reference is made to the interesting fact that the highest temperature will, in calm weather, be found not at the very surface but just beneath. Consequently disturbance of the sea surface causes at first a slight rise in surface temperature, but thereafter a fall. This is clearly displayed by means of diagrams in which the amount of sea-disturbance is plotted against temperature, given as a difference. (There is a slip in diagram 3; the longitude should be E.)

The curves so obtained are compared with hypothetical curves, but the source from which these latter curves are derived is not made clear. From this comparison the deduction is made that under "calm" or "very smooth" conditions the method of observation (i.e., sampling with a bucket) does not permit the temperature of the actual surface to be accurately

observed, owing to the disturbance caused by the ship, etc. With greater disturbance the mixture of the upper layers will be so complete that the observations obtained may be regarded as referring to the actual surface. It is interesting to note, however, that the author's preference is for observations with buckets rather than from the condenser-inlet.

The difference between the average temperature for mean smooth and for mean moderate conditions amounts to about $^1/_2$° C. for most of the regions investigated. Only in the equatorial Atlantic this difference is $^1/_4$° C. Another effect, experienced in a less degree in the equatorial Atlantic again, is the reduction of the daily range by about 0.16° C., for a similar change of sea-disturbance. J. R. L.

Jerry H. Service. Measurement of Salinity of Seawater. U. S. Coast and Geodetic Survey: Special Publication, No. 147. Washington, 1928.

The United States Coast and Geodetic Survey makes wide use of the radio-acoustic method of ranging for the purpose of fixing positions at sea when out of sight of land. It is necessary that the velocity of sound in the waters under survey should be known, and this is preferably calculated from the salinity and temperature. The salinity has a comparatively small influence on the velocity, and it is sufficient if it is known with no uncertainty greater than two or three units in the first decimal place. The methods of determining salinity described in this paper reach this standard of accuracy and can be used on board ship in ordinary surveying weather. They are those by hydrometer, by titration, by determining the refractive index with the dipping refractometer, and by balancing a column of the water against one of kerosene.

D. J. Matthews.

Marie V. Lebour. The Larval Stages of The Plymouth Brachyura. Proc. Zool. Soc., pt. 2, 1928, pp. 473—560, plates 1—16, textfigures 1—5. London 1928.

From the waters at Plymouth 37 species of Brachyura are known. Miss Lebour has traced the larval stages of all these species, except four, but the development of two of these has been described by others. As far as possible the larvæ were hatched from eggs from berried crabs, and the development has then been continued in the laboratory. In other cases (even when the adult crabs are rare or not to be found) the larvæ occur sometimes in the plankton. A few were reared from egg to crab, others from egg to megalopa; thus there is no doubt as to the identification of the species. Sometimes the gaps were filled with material from the plankton.

The paper is divided up into several sections, the first of which contains general characteristics of the larval stages partly from a morphological, partly from a systematic point of view. Probably all the British crabs hatch from the egg as a pre-zoëa (enclosed in an embryonic skin of extreme thinness and thus quite unable to swim) with a free existence of at most some hours, and this stage gives rise to the first zoëa (with two pairs of

swimming maxillipedes). The crab zoëæ have ordinarily a long rostral and a long medio-dorsal spine and in addition a pair of lateral spines on the carapace. The third larval stage, megalopa, is still freeswimming (but by means of the abdominal limbs) and has all the legs fully developed and functional. Then comes the young crab stage. There may be up to 5 zoëal stages, but rarely more than a single megalopa stage.

Apart from the number of zoëal stages (2, 4 or 5) the following morphological characters are used in the identification: presence or absence of spines on the carapace; character of the antennæ; character of the telson and its armature; armature of the abdominal segments.

The carapace has usually a long rostral and a long dorsal spine (turned backwards) and a pair of lateral spines. The rostral and dorsal spine are more or less in elongation of each other and help mainly in directing the movements of the zoëa, but also help together with the other outgrowths of the body (lateral spines, abdominal spines, limbs, etc.) in keeping it up in the water. The reduction of these spines appears to be associated with habits of life near the bottom, and as closely-related species may or may not have certain spines, too much importance must not be attached to them except for convenience in identification.

The antennæ are well developed in all genera except Ebalia and Pinnotheres, where they are only rudimentary stumps. Sometimes the exopodite is very long, for instance, in the Inachinæ; Miss Lebour is of opinion (and probably justly) that the long exopodites are compensation for the absence of rostral spine in this subfamily.

The abdomen of the crab zoëæ has always a pair of hook-like lateral knobs on the second segment; sometimes there may be similar knobs also on other segments. In vain the author has tried to conjecture the significance of the knobs; possibly it is a primitive feature to have them on many segments.

The telson is forked (except in Pinnotheres and a few other genera), with lateral spines; the most primitive telson is probably that with six spines or setæ on each side (three on the lateral side, three on the inner side of the fork).

In the systematic section the author gives descriptions of all the investigated larval stages, accompanied with numerous (partly coloured) drawings, and with keys to the larval stages in order to identify the genera. There are also numerous notes on habits, foods, etc., and a list of breeding-times and seasons for larvæ of the Plymouth crabs. Finally come some considerations on further work on larval stages on some non-British crabs. When compared with the last great paper on northern Brachyur larvæ, viz., Williamson's account in the "Nordisches Plankton" of 1915, it is clear what enormous advances our knowledge has made in recent years.

The most interesting of Miss Lebour's investigations are the contribution of the larvæ (confirmation or the reverse) to the existing classification of the adult. Upon the whole there is very good agreement between the system based on the larvæ and that based on the adult. The three sections of Brachyura, viz., Brachyrhyncha, Oxystomata and Oxyrhyncha, may be partly separated as early as the pre-zoëal stage, and for the most part the larvæ fit in with the classification: genera considered closely

allied are in the larval stages already near to one another, and in the prezoëa the Portunidæ (Portunus, Bathynectes, Carcinus) may be separated with certainty from the very nearly related families Cancridæ and Xanthidæ. In the zoëal stages it is possible to separate not only the genera, but usually also the species, and even in those cases where the genus has several species (Portunus, with 7 species).

The most recent classifications consider the Oxyrhyncha as not so primitive as the Brachyrhyncha, and this agrees well with our knowledge of the larvæ. The Oxyrhyncha have, for instance, abbreviated life histories, and there are several very important characters separating them from the Brachyrhyncha; only the Pinnotheridæ do not fit in the system, and the Oxystomata take a position between the other two groups.

Though, as it appears from the larvæ, the system of the adult seems to be a fairly natural one and to be confirmed through studies on larvæ, there is nevertheless some disagreement.

Eurynome (fam. Parthenopidæ) is in the larval stages very like Maia (fam. Maiidæ), but it is quite different from the larvæ belonging to its own family, which are described.

Pinnotheres takes the most remarkable position. The Pinnotheridæ are usually placed near the Grapsidæ (Brachyrhyncha), but the larvæ have a close resemblance to the genus Ebalia (fam. Leucosiidæ, Oxystomata). Of the Oxystomata only a few genera are known in the larval stages, viz., Dorippe, Ethusa, Ebalia, and Leucosia. The zoëæ of Dorippe and Ethusa are quite different from those of the two other genera: they have the rostral and dorsal spine extremely long, the abdomen is extremely long with the telson forked, and the lateral spines of the carapace may be present (Ethusa) or absent (Dorippe), but upon the whole these larvæ are not very different from the usual type of Brachyur larvæ. The zoëæ of Ebalia and Leucosia (both belonging to the fam. Leucosiidæ) have quite another shape; rostrum may be long (Leucosia) or rudimentary (Ebalia), and as the lateral spines of the carapace are rudimentary and the dorsal spine is lacking, the carapace has a pea-like appearance; the abdomen is rather short, and the abdomen is never forked, but more or less triangular or trapezoid. Now the zoëæ of Pinnotheres are very nearly of the same type as the two last-named genera except that the telson is three-lobed (it has a tongue-shaped process in the middle of the hind margin). Also the megalopæ of Pinnotheres have two remarkable characters: no rostrum and no curved spines ("feelers") on the last pair of legs.

Miss Lebour's paper is a fine continuation of the shining traditions of the work on larval development, shaped especially by G. O. Sars about half a century ago, and it evinces highly both the author's indefatigable studies and the excellence of the Plymouth Laboratory; it is to be hoped that in years to come the author will be happy enough to fill up some of the gaps still existing as to our knowledge of the larval development of the British Brachyura.

K. Stephensen.

Leif Störmer. Copepods from the "Michael Sars" Expedition, 1924. Cons. Perm. Intern. pour l'Exploration de la mer. Extrait from Rapp. et Proc. Verb. Vol. LVI, Copenhagen 1929.

The most important part of Mr. Störmer's interesting paper is that dealing with the development and migrations of *Calanus finmarchicus* off the west coast of Greenland. He seeks to explain the occurrence of two size-groups, and comes to the conclusion that the larger individuals which are found at the northern stations, were spawned in Greenland waters during the previous summer, and were therefore over a year old; while the smaller specimens, which are characteristic of the southern stations, were spawned farther south in the spring of the same year, and had been carried north by currents. As adult stages were comparatively scarce, his observations are based on individuals of the fifth copepodite stage. He found the vertical distribution to be as follows:—

Nauplii and First Copepodites: 50—0 m. exclusively.
Second Copepodites: 100—0 m. exclusively.
Third Copepodites: mainly in upper 100 m. but may be deeper down.
Fourth and Fifth Copepodites: at all depths.
Adult ♀ mainly 100—50 m., or scattered throughout all depths.
Adult ♂ between 300—50 m.

There is a northerly current along the west coast of Greenland, the surface waters of which have a somewhat greater velocity than the underlying ones; further, there is a wedge of cold water extending southwards over the banks. These two conditions are important factors in the distribution and development of the young stages of *Calanus* which are derived from spawning on the banks. The youngest stages are in the warmer and swifter moving surface waters, while the older stages have migrated downwards into the colder and more sluggish water. This power to migrate seems to be acquired by *Calanus* at about the third copepodite stage. The cold water retards development — even during August — and as the copepods move north and west they get into still colder water. The individuals tend to remain at stages III and IV for a considerable time, and assuming a steady spawning throughout a lengthy period, there would be a great preponderance of these stages, which Mr. Störmer finds to be the case. Autumn and winter follow, and development continues to be slow, and leads to the production of larger individuals than usual. We are left in some doubt as to the fate of the younger stages that are carried north in the surface waters.

Calanus appears to remain in the fifth copepodite stage until conditions are favourable for spawning, when it passes through the relatively short period of maturity.

Similar observations were made on the principal copepod species collected during the expedition, but it was not always possible to separate the early copepodite stages so readily as in the case of *Calanus finmarchicus*. Evidence was found of a more or less definite spawning of *Calanus hyperboreus* in the Norwegian Sea: the vertical distribution of *Pseudocalanus minutus* (= *elongatus*) agreed fairly well with that of *Calanus finmarchicus*. An interesting feature of the vertical range of the stages of

Euchaeta norvegica was that the smallest copepodite stages were found at deeper levels than the larger ones; a result which he finds does not agree with previous investigations; it is not, however, inconsistent with BIGELOW's results in the Gulf of Maine; he found *Euchaeta* to be almost limited to the waters below 100 metres, and states that reproduction takes place entirely below that depth.

Oithona helgolandica was very common and composed 48.2 per cent. of all the copepods counted in surface samples (50—0 m.). *Oithona spinirostris* had a more restricted distribution and appeared to follow the warm Atlantic water which lay beneath the colder water from north and west.

R. E. S.

WINFRED EMORY ALLEN. Quantitative Studies on Inshore Marine Diatoms and Dinoflagellates, collected in Southern California in 1924." — Bulletin of the Scripps Institute of Oceanography, La Jolla, California. Technical Series, Vol. I. No. 15. 1928.

— "Review of Five Years of Studies on Phytoplankton at Southern California Piers, 1920—1924 inclusive. — Ibid. No. 16. 1928.

In the first of these papers Mr. W. E. ALLEN continues the description of his plankton researches in Southern California, the sixth of the series; in the second he brings the results of five years work together in review.

As in preceding years daily collections were taken throughout the year at three piers, Scripps Institute of Oceanography, at La Jolla, Oceanside and Pt. Hueneme. The great excess in numbers of diatoms at Pt. Hueneme and the exceptional maximum at La Jolla in 1924 is noteworthy, and dinoflagellates were so numerous at La Jolla in June that there was a distinct discoloration of the water, the most prominent case of "red water" for years. The chief species causing discoloration was *Prorocentrum micans*. After the disappearance of the red water came "stinking water" which is usually supposed to be the direct consequence of the former. In this the most important organism was a tintinnid although numbers of peridinians and a few diatoms were present. Earlier cases of red water were chiefly due to *Gonyaulax polyedra* and it is interesting to find that from time to time especially in latter years the cause was *Prorocentrum micans*.

The methods used successfully by Mr. ALLEN for the five years described (1919—1924) include dipping, measuring and filtering through No. 25 Dufour bolting silk (average diameter of mesh about 0.05 mm.) of the samples to be studied. All enumerations were made by use of the Sedgwick-Rafter counting cell and the Whipple ocular disc micrometer.

There is considerable variability in annual production of diatoms and dinoflagellates in the Southern Californian region in general and in some localities in particular, the total number of diatom cells at Pt. Hueneme for the five years being more than one-fourth greater than the total at La Jolla, those at Oceanside being less than either, but there has been a steady decline in numbers after 1921 at La Jolla and a steady increase at Pt. Hueneme, the reason being obscure and apparently in no way due to temperature and salinity. The seasonal distribution, however, agrees

in most years in the second quarter of the year being the most productive for diatoms, only thirteen species belonging to five genera being dominant. The most important is Chaetoceros (chiefly *C. curvisetus* and *C. debile*, both common northern species). So outstandingly prominent is this genus that there is good reason to think that the Southern California region, and especially the Gulf of Santa Catalina, gives exceptional opportunity for its development. Dinoflagellates occur in much smaller numbers but there is no indication that they are most abundant when diatoms are on the decrease, sometimes they are both at their maxima at the same time. Three genera of dinoflagellates are dominant, the leading species being *Prorocentrum micans*, *Ceratium tripos*, *C. furca* and *C. fusus*, *Peridinium divergens* and *P. depressum*, all common northern species. The large bulk of the individual dinoflagellates compared with the diatoms make them, when present in numbers, very important as food for various organisms. *Prorocentrum micans* is a common food of the mussel *Mytilus californianus*, just as it is with the northern mussels and oysters.

Observations on fishes seem to indicate that the Californian sardine and mackerel are most abundant at the time of maximum abundance of diatoms, apparently especially when *Nitzschia seriata* is to the fore. This diatom, also a common northern species, is constantly present in the plankton, often in great numbers and it is certainly one of the most important of the southern Californian species. It is interesting to note that the author found less diatoms with increase of sunshine and *vice-versa*, his results thus agreeing with those of Marshall and Orr at Millport who found that too much sunlight was deleterious to diatom growth.

The fact that the most important diatoms and dinoflagellates in these researches are all common to both Californian waters and to the northern seas makes the results specially interesting to workers in both regions.

M. V. L.

F. S. Russell. The Vertical Distribution of Marine Macroplankton. VIII. Further Observations on the Diurnal Behaviour of the Pelagic Young of Teleostean Fishes in the Plymouth Area. Journal of the Marine Biological Association, New Series. Vol. XV, No. 3. pp. 829—850. Plymouth 1928.

In two former papers in this series Mr. Russell dealt with the distribution of young fishes as shown by hauls of a two metre stramin ring trawl at successive depths checked by a depth recorder. These observations were supplemented by a further set, made in a similar manner in 1926, five series of hauls being made at intervals from daylight on June 3rd to daylight on June 4th, each at six successive depths down to 36 metres over a total depth which is not stated, but which seems from the position, two miles east of the Eddystone, to have been about 55 metres, and an account of these latter observations is given in the paper under review.

The results as a whole agree well with those recorded in the third paper of the series, which was reviewed in Vol. II, No. 1 of this Journal. As before Clupeoids and Callionymus made up the main portion of the catch, but satisfactory numbers of some other species were taken. The

Clupeoids, small *C. sprattus* and *C. pilchardus*, show an immense increase of numbers by night, due evidently to migration below the depths fished (35 m.) during daylight. How close to the bottom they go is still not known. *Gobius* sp. also showed a well marked increase in the catches during the night. The Gadoids, mainly whiting, especially those of over 12 mm., are correlated with the presence or absence of the medusa *Cyanea capillata* and the vertical movement towards the surface which they show at dusk is a joint one. Specimens under 11 mm. in length have an irregular distribution and are apparently not associated with Cyanea. *Scophthalmus norvegicus* occurred in satisfactory numbers and measurement of the specimens showed that a nocturnal increase in the upper layers was due to the presence of specimens over 8 mm. in length, the numbers of the smaller sizes remaining constant. Scophthalmus also showed a clearly indicated concentration at about 4 metres at daylight on the morning of June 4th, as did also Callionymus. This at first sight seems to be irregular, but the suggestion is made that the presence of a very dense swarm of *Calanus*, which was observed at the time, may have caused a shading which stimulated the rise. None of the other species taken showed any evident increase of the numbers in the upper layers or in the total catch by night.

The author points out that in order to get a true picture of the distribution of Clupeoid larvae it would be advisable to make collections by night. For the other species, except Gobius and Callionymus, which are not of great economic importance, daylight hauls would seem to be sufficient. G. P. F.

J. H. Orton. Observations on Patella vulgata. Part I. Sex-Phenomena, Breeding and Shell-Growth. Part II. Rate of Growth of Shell. Journal of the Marine Biological Association, New Series. Vol. XV, No. 3. pp. 851—874. Plymouth 1928.

In these two papers Dr. Orton has gathered together a number of detailed observations made on the Common Limpet, which throw some light on its life history. From examination of a very large number of specimens he finds that in the young stages, up to 20 mm. in length, the proportion of males is very high, in some samples as high as 81 per cent., with a considerable number of undifferentiated sex and the proportion of females sometimes as low as 3.1 per cent. In the older stages of large size this state of affairs is partially reversed, 64 to 68 per cent. of females being present. The author cites observations of Gemmill and Pelseneer which confirm his own and he considers that the Limpet is mainly a protandric hermaphrodite, explaining the presence of so many males of large size by the suggestion that there may be two types of Limpet of different genetic constitution, one a pure male which never becomes a female, the other a hermaphrodite which starts life as a male.

The building of a new concrete wharf at Plymouth offered an opportunity of observing the rate of growth. It is well known that Patella, being a sluggish animal, rarely wanders far from the spot on which it first settles, and as the date of the construction of each pile of the wharf was known, the maximal age of the limpets on it could be determined and the rate

of growth of the produce of two successive breeding periods estimated with considerable accuracy. It was found that in 1912 the growth in length of limpets in their first year amounted to 26—35 mm., and in 1913 to 11—27 mm. At an age of two years the two broods measured respectively 53 mm. and 47—49 mm. This is regarded as an exceptionally high rate of growth, the climatic conditions being favourable and the position such as to induce a flat form of shell in which increase in length and breadth are made at the expense of height. It was found by observations in other localities that the greater the degree of exposure to dessication the higher the shell is in proportion to its length and breadth. The breeding season of the Plymouth limpets is recorded as from August to March with a maximum in January and February.

Other points touched on in the paper are the indications of a check in the growth rate at midsummer and the change of shell shape at a size when the female first attains sexual maturity, and the need for further observations on these points is alluded to. G. P. F.

Erik M. Poulsen. The Haddock in the Belt Sea and the Western Baltic during the Years 1926—1928. 34th Report of the Danish Biological Station, VI. pp. 99—125. Copenhagen, 1928.

This paper, a sequel to that of Johansen[1]), describes in detail the most recent biological work on the Haddock of the Western Baltic. There the waters are unsuitable for the rearing and sustentation of an indigenous Haddock stock, but occasionally, at what the author of the paper thinks are long intervals of years, an unusually pronounced inflow of Atlantic (high-salinity) water in spring brings with it sufficient larvae to provide later a season or two of lucrative fishing for sizeable adolescent fish. Such an inflow occurred in 1923, and, as is conclusively shown, gave rise to a very successful Haddock fishery three years later, in winter, 1926. Table I gives the yield by weight of the Belt Sea catches from 1909—1928. In ten of these years the yield was nil. Indeed for the years prior to 1923 positive results were obtained in only four years, when the influence of the 1909 and 1913 broods was at work. Thereafter a further period of nil returns is recorded for the years 1917—1922, followed by a period showing increasing yields up till 1926, when abnormally large weights of Haddock of the 1923 year class were landed. Since the departure of this brood (or rather the maturing portion of it, which Johansen correctly anticipated would form about 90 per cent. of the total) to spawning grounds outside the Western Baltic the weight of Haddock caught has declined, although in 1927 and 1928 it was still well above the average. The author notes that larvae of the 1926 brood were scarce in these waters but that a good few larvae and early bottom stages of the 1927 and 1928 broods were found. He therefore anticipates catches of the more moderate sort in the next few years. It is of importance to note that the 1928 brood

[1]) A. C. Johansen: — On the Remarkable Quantities of Haddock in the Belt Sea during the winter of 1925—1926, and the Causes leading to the same (Journal du Conseil, Vol. I., No. 2, 1926).

— the most successful in the North Sea since that of 1923 — is not expected to increase the Baltic catches to any great extent. We ourselves find that this brood is more confined to the northerly latitudes of the North Sea. POULSEN finds the inflow of high-salinity water to the Baltic to have occurred later than it did in 1923 — i .e., in early summer — too late, indeed, to bring with it large numbers of small larvae.

The Haddock stock of the Western Baltic seems then to be derived mainly as follows:—

(a) from the upgrowth of a (usually restricted) number of larvae drifted in with the inflow of high-salinity water. Exceptionally (in 1923 e. g.) an early and strongly accentuated inflow of such water enormously increases the number of larvae brought in, so that a lucrative fishery develops two to three years later.

(b) from an irregular but small number of what we may term "pre-spawning" feeding immigrants from the Kattegat or even beyond. These, along with the maturing fish of (a) depart suddenly about February — the month of rapid migration to the spawning grounds. Now the fish of (b) are themselves insufficiently numerous to give rise to a profitable Haddock fishing, but the author shows that by making quantitative studies of the incoming larvae of (a) the course of the fishing can be estimated some years ahead.

Age determination was carried out by means of scale-reading. No mention is made of any difficulties encountered in doing this, but one observes that about 4 per cent. of the fish have not been allotted an age. It would have been of interest to other workers to have had the author's comments on this point. The 1922 brood — that most meagre of North Sea broods — is shown as having been much more plentiful in the 1926 than in the 1925 catches, and it would be reassuring to know that no difficulty had been met with in making the age-assessments. In 1926 age determinations were made for 305 fish, in 1927 for 278, and in 1928 for 84. The 1923 brood comprised 99, 79 and 77 per cent. respectively of these three samples. This leaves a rather meagre number of fish of other broods and it is unprofitable to make more than very general deductions therefrom. Thus the fresh immigration of adult fish — suggested by the author as having occurred in 1926—27 — was probably inconsiderable. The fall of the percentage of 1923 brood fish from 99 to 80 can indeed be largely accounted for (to the extent of 11 of the total difference of 19 per cent.) by the immigration of the adolescent 1925 brood.

The growth rate of Haddock in the Belt Sea is shown to be about equivalent to that at Iceland and much greater than in the North Sea generally. It is probable that the author places the growth for the first year much too low at about 15.5 cms. This size is obtained by calculation from scale-measurements, and no mention is made of any correction having been added to the average calculated l_1 to compensate for the well-known size deficiency to which this procedure gives rise.

The author finds that echinoderms, which form a large part of the food of North Sea Haddock are, in the diet af Western Baltic Haddock,

largely replaced by molluscs, crustaceans and annelids. The diet of the Baltic Haddock therefore seems to be intrinsically the more nutritive and likely to stimulate rapid growth. Comparison of the species of food animals available on different grounds is, however, of doubtful value unless the observarions relate strictly to similar seasons of the year. The Belt Sea Haddock referred to in this paper were presumably mostly captured in the period December to February; the fish from the Kattegat were taken in April (and contained molluscs but no echinoderms), whereas Blegvad is cited as having found in another sample of Kattegat Haddock many echinoderms and no molluscs; and the North Sea Haddock were taken during the period August to December. It is a fault of most of the work which has already been done in working out the food of the Haddock that the results are not expressed in such a form as to show strictly comparative values. It would probably be better, then, if the food-analysis given in Table 7 of this paper expressed a definite volume (c. c's per 10 or 100 stomachs) for each group of food animals found in the stomachs. By means of a table of nutritive values, worked out chemically for each food-animal group, this volume could be converted to a value expressing units of energy and directly comparable with values similarly worked out in other seasons and localities.

In the North Sea a fair proportion of Haddock become mature at the end of the second year of life, and practically all by the end of the third year. Poulsen finds much the same course of events occurring in the case of the Western Baltic Haddock, with this exception, that while nine male fish out of 14 examined were maturing in the second winter, none of the 18 female fish examined were. Convincing evidence is given that "the Haddock can certainly develop ripe eggs and milt in the comparatively low salinity of the Belt Sea water (ca. 22 ‰); also that, as a rule, no larvae develop from the eggs spawned". This discovery forms an important contribution to the study of the physical factors affecting the spawning fish. The author is naturally tempted to make a study of the possibilities of hatching Haddock for the purpose of stocking a sea where growth is so encouragingly rapid. It would appear from his statements that the difficulty is not the usual one of carrying the fish past the post-larval stage but the actual fertilisation of the egg and subsequent development from the latter up to the larval stage. H. T.

A. Bowman. Line fishing in the Moray Firth during the period 1904—1916 (inclusive). — Fisheries, Scotland. Sci. Invest. 1927, II. Edinburgh, 1928.

In ähnlicher Weise wie beim »Kabeljaunetz« und bei der Wade behandelt hier der Verfasser die Langleinenfischerei im Moray Firth. Alle diese drei Abhandlungen sind gewissermassen Monographien verschiedener fischereilicher Betriebsarten in ihrem Zusammenhange mit biologischen Verhältnissen in einem Gebiet, das in mancher Beziehung eine Sonderstellung einnimmt. In der vorliegenden Abhandlung gibt der Verfasser einleitend eine kurze Übersicht über die drei Methoden dieser Fischerei, nämlich die »Grossen Leinen«, die »Kleinen Leinen« und die »Handleinen«,

sowie deren Anwendungsweise. Auch die Gebiete, in denen die einzelnen Formen angewandt werden, und die Fische, die den Hauptfang bilden, werden kurz erwähnt. Dann geht der Verf. im einzelnen auf die Veränderungen ein, denen diese Fischerei im Laufe der Zeiten unterworfen gewesen ist. In einem weiteren Abschnitt werden die Ergebnisse dieser Fischerei behandelt, und zwar getrennt sowohl nach den drei Methoden wie nach den einzelnen Distrikten. Die Fischerei mit den »Kleinen Leinen« bildet das Rückgrat dieses Betriebes, und der Schellfisch ist das hauptsächlichste Fangobjekt. Der Fang mit Handleinen, der nur in unmittelbarer Nähe der Küste betrieben wird, gilt hauptsächlich dem Kabeljau und wird in erster Linie im nordwestlichen Teil des Gebietes ausgeübt.

Von Interesse sind auch die Untersuchungen über die Stärke der Befischung mit den genannten Geräten überhaupt wie über die jahreszeitlichen Schwankungen der Befischungsstärke. Dabei stellte sich heraus, dass jede der drei Methoden ihre eigenen charakteristischen jahreszeitlichen Schwankungen aufweist. Die Erörterungen über die Fluktuationen ergeben auf statistischer Grundlage wertvolle biologische Rückschlüsse, besonders über die beiden Hauptfangobjekte Schellfisch und Kabeljau.

In einer Schlussbetrachtung werden die Hauptergebnisse noch einmal kurz zusammengefasst. Von besonderem Interesse sind die in diesem Zusammenhang gegebenen, kurz und klar formulierten Angaben über die biologischen Verhältnisse des Schellfisches im Moray Firth, des Fisches, der nicht nur in der dortigen Langleinenfischerei die grösste Rolle spielt, sondern der auch bereits seit längerer Zeit ein besonderes, wichtiges Untersuchungsobjekt des Laboratoriums in Aberdeen bildet. Es wird erwähnt, dass die Hauptmenge der jüngeren im Moray Firth vorkommenden Schellfische aus Laichgebieten ausserhalb des Firth stammen, und dass die Bevölkerung in erster Linie durch passive Einwanderung pelagischer Stadien erfolgt oder auch durch aktive Einwanderung späterer Bodenstadien. Wir erfahren weiter etwas über das erste Erscheinen des jungen Nachwuchses in den Fängen und über die Zeit der Erlangung der Marktgrösse und der Geschlechtsreife, sowie über die Auswirkungen der biologischen Vorgänge auf die Fischerei. Ferner werden einige Angaben über einzelne für die Entwicklung der Brut besonders günstige Jahre und darüber gemacht, wann diese Einflüsse sich zuerst in der Fischerei geltend machen, und wann sie ihre grössten Auswirkungen zeigen. Ähnliche, aber kürzere Angaben werden auch über den Kabeljau gemacht.

SCHNAKENBECK.

GUIDO SCHNEIDER. Die Seefischerei von Lettland und Estland. Handbuch der Seefischerei Nordeuropas, Bd. VIII. Heft 6. (34 pag., 18 fig.). Stuttgart. 1928.

The author gives a short account of the sea fishery in two states, newly created after the great war. The sea fishery in this part of the Baltic, although prosecuted for centuries, remained in a somewhat primitive condition but is steadily increasing and developing. Very interesting is the account of the organisation of the fishery during the temporary sojourn of the German army during the war, and the introduction of new laws after the establishment of the independence of Latvia and Esthonia.

An account of the hydrographical conditions of this part of the Baltic shows the peculiar features of the sea fishery. In the chapter dealing with the different kinds of fish, the author points out the importance and the possibility of developing the herring fishery. This fish forms more than 50 per cent. of the total catch of fish in both countries. The author justly criticises the statistical figures for the herring fishery in Esthonia and is of the opinion that the whole coast of both countries, which now-a-days produces about 15,000 tons of herrings, can produce much more with increased intensity and better organisation of the fishery. — Very valuable details are to be found in the short but very cleverly made accounts of other fishes, especially the sprat, salmon and flounder.

The statistical figures, carefully examined by the author, lead to the conclusion, that now-a-days the whole coast of both countries produces about 31,000 tons of fish, of the value of about $5^1/_2$ Millions shillings yearly.

The descriptions of fishing gear, methods of fishing and boats show that the fishery, here retaining in many cases primitive forms has chiefly the character of a coastal fishery.

The account of the ports and the administrative division of the coast terminates this very valuable and interesting paper, which forms one part of the large work on the sea fishery in Northern Europe. From that account one conclusion clearly emerges, that in such countries as the two which are treated in the work of Prof. Schneider, the actual state of the fishery indicates the greatest possibilities for development. M. S.

Paul S. Galtsoff. Experimental study of the Function of the Oyster Gills and its bearing on the Problems of Oyster Culture and Sanitary Control of the Oyster Industry. — Bulletin of Bureau of Fisheries XLIV. Document No. 1035. Washington 1928.

Though the importance of efficient administration of measures designed to deal with cultural problems and the sanitary control of shellfish cannot be overrated, they must obviously be based on sound scientific knowledge.

The research described in this paper was undertaken by Prof. Galtsoff to fill part of a gap in our knowledge of the physiology of the American oyster (*Ostrea virginica*) and relates to a function which has an important bearing on practical problems.

The capacity of the oyster and other shellfish for filtering water has long attracted the attention of investigators. Various methods have been employed for measuring the strength of currents produced by plankton feeding organisms, but the results differ for the same organism to a remarkable extent, and practically no attention has been given to the influence of temperature. These methods are reviewed by Prof. Galtsoff in an introductory section of this paper, in which he also devotes a few pages to the present position of bacteriological standards in the United States. He indicates that difficulties experienced there in connection with sanitary control are due partly to lack of knowledge of the relation between the temperature of polluted water and the degree of pollution of oysters taken from it, or of polluted oysters relaid in clean water. In this connection it

may be noted that Dr. DODGSON's comprehensive "Report on Mussel Purification" deals fully with these problems and with bacteriological standards and methods, and it must be admitted that some of the difficulties experienced in the United States are due to methods which are open to grave criticism; such, for example, as the testing of shell liquor only, without including portions of the minced meats of the oysters under examination. On the other hand, the value of an understanding of the filtering function is amply confirmed by Dr. DODGSON's observations in the case of the mussel; the rapid clearing of water by mussels under treatment being an immediate and sure indication that cleansing is proceeding normally. Prof. GALTSOFF's experimental work deals with the effect of temperature on the rate of flow of water through the gills, with their filtering capacity, and with the action of the adductor muscle. For the gill investigation he has devised two direct methods, each meeting a special requirement. One, the tank method, enables the filtered water to be collected and examined and gives a direct reading of pressure. In the other, measurement of the rate of flow of water through a tube enables the volume passing through the gills, and the pressure, to be calculated from Poiseuille's formula connecting the factors which are involved. The mechanical work performed by the gills can also be arrived at.

Criticism may be made that the oysters were tested under highly abnormal conditions; the valves being forced and wedged apart, then a tube inserted between them, and the adjacent space packed. Incidentally, fuller details of this procedure might with advantage have been given. Susceptibility to mechanical disturbance was, however, shown to last only for a few minutes; the effect of preparing the oysters in this way may therefore be equally brief, and probably normal pressure is rapidly established in the gill cavities. Whether it be so or not, the two methods give comparable results, and in a series of many experiments, involving some thousands of readings, Prof. GALTSOFF has been able to establish a consistent relationship between temperature and current production by the gills, though individual oysters different widely from each other in the amounts filtered under the same conditions, the variations increasing with the temperature. Increased rate of flow always accompanied rise in temperature within a certain range. In most of the oysters tested, current began at about 8° C., and in summer reached a maximum averaging 2.5 litres per hour between 25° and 30° C. The maximum amount recorded for one oyster was 3.9 litres per hour at 25° C., but another oyster at the same temperature produced a flow of only 0.9 litre. The commencement of current at about 8° C. occurs not only in oysters cooled in the summer but also in hibernating oysters (an expression seldom used in Europe, but widely employed in the United States). The difference between rate of flow with oysters tested in summer and in winter, at the same temperatures, is well marked; the increase with rise of temperature between 7° and 15° C. being very small in the winter. The presence of mucus clogging the lateral cilia of the gills in oysters taken from cold water is regarded by the author as being very probably the factor responsible for this result. In the matter of filtering water, it is possible that factors other than rate of ciliary movement are involved. The clearing of turbid water by mussels

in tanks has already been referred to. Dr. Dodgson has noted that the minimum time required to produce absolute clarity is independent of temperature, over a wide range from 1° C. to 16° C., the maximum amount filtered per mussel being no less than about 2 litres per hour. Such clearing is therefore not directly proportional to the rate of beat of the frontal cilia as determined by Gray.

Prof. Galtsoff found that a very large percentage of plankton organisms are filtered out by the gills, but unter the conditions of his experiments up to nearly 90 per cent. of bacteria may pass through the oysters gills and be ejected.

By means of counterbalanced attachments to oyster shells, operating pens on a time recorder disc, he also investigated the opening and closing of a number of oysters, and concluded that there is no correlation between closures of shell and hours of darkness. Similar conclusions with *O. edulis* have been drawn by Webb at Conway. The author found an average of open hours to be 17 out of the 24, there being no visible effect of temperature between 13° and 22° C.

In the practical application of this valuable work, caution is desirable. The production of dejecta by the gills does not necessarily connote activity of cilia lining the gut. A clear distinction between material rejected by the gills ("pseudo-faeces") and true faeces is desirable. Production of the latter is good evidence of satisfactory activity of the whole organism. This indication, in support of suitable bacteriological tests, has been used by Webb, who has found the critical temperature for the cleansing of *O. edulis* to be identical with that at which Prof. Galtsoff noted definite currents to begin in the gill cavity, viz. 8° C., but the pseudo-faeces are produced from about 4° to 5° C.

The author concludes from his results that temperature is an important factor in growth and fattening also.

Prof. Galtsoff may be congratulated on having attacked problems with success by direct methods which present considerable practical difficulties. He has obtained valuable results, and if improved methods are discovered later, by which the rate of flow produced by oyster gills be found to exceed his figures, the practical value of his work will still remain. The paper makes interesting reading, and includes a useful summary and bibliography. H. P. S.

Current Bibliography.

Prepared by the Editor with the assistance of Miss THURSBY-PELHAM.

NOTE. The scope of the Bibliography is limited in the main to the area covered by the Council's activities, but there are included papers of general interest relating to other areas in the North Temperate and Arctic regions and exceptionally elsewhere. Limnological references are not as a rule given, but papers relating to brackish waters and to salmon and freshwater fish studied by the Council are included.

The classification of entries follows in a general way that adopted in Dr. ALLEN's Selected Bibliography published in Vol. I, Nos. 1 and 2 of the Journal, and since reprinted.

Subscribers and those on the distribution list will receive regularly upon application to the Administrative Secretary copies of the Bibliography printed on one side of the page only, for use in making up card indices.

The Editor will be glad to be advised of emendations and additions to the Bibliography.

Physical and Biological Conditions in the Sea.

GENERAL HYDROGRAPHY

Beaugé, L. Rapport de Mission sur le Banc de Terre-Neuve (Campagne 1927) 1ère Partie. Rev. des Trav. de l'Office des Pêches Mar. I, Fasc. 2, 27—86, 1928.

de Buen, R. Étude générale du système hydrologique du Secteur Sud. Rapp. Atlantique. Rapp. et Proc.-Verb., LV, 50—110, 1929.

Charcot, J. B. Rapports préliminaires sur la campagne du "Pourquoi Pas?" en 1926 et 1927. Ann. Hydr., Paris. 1927—28.

Claude, G. Sur l'utilisation de l'énergie thermique des eaux. C. R. Acad. Sci. Paris, CLXXXVIII, 1460—61, 1929.

Le Danois, E. Le sondeur ultra-sonore "Langevin-Florisson". Rev. des Trav. de l'Office des Pêches Mar. I, Fasc. 2, 4—10, 1928.

Le Danois, E. Remarques hydrologiques (Secteur Nord) Rapp. Atlantique 1927. Rapp. et Proc.-Verb., LV, 29—49, 1929.

Gill, R. Hydrography of Northumberland Coastal Waters. Rep. Dove Marine Lab. for year ending June 30th, 1928, 39—46, 1929.

Hydrographic Dept. Leningrad. The State of Ice in the Seas of the U. S. S. R. Fasc. III. The Winter 1926—27, Hydrographic Dept. Leningrad. 1928.

Jacobsen, J. P. Contributions to the Hydrography of the North Atlantic. The Dana Expedition 1921—22. The Danish Dana Exps. 1920—22, in the North Atlantic and Gulf of Panama. Ocean. Rep. edited by the Dana Com., III, Copenhagen. 1929.

Jensen, A. J. C. Remarks on the Hydrography of the Limfjord. Rep. Danish Biol. Stat. XXXIV, 15—32, 1928.

Lallemand, Ch. et Prévot, E. Variations lentes du niveau moyen de la mer sur le littoral français. C. R. Acad. Sci. Paris, CLXXXVIII, 1345—48, 1929.

Marmer, H. A. Hydrographic Datum Planes. Hydrog. Review, VI, 37—52, 1929.

Martens, E. Hydrographical Investigations in the Norwegian Sea off Møre 1925—28. Rapp. et Proc.-Verb., LVI, 1—7, 1929.

Martens, E. Hydrographical Investigations during the "Michael Sars" Expedition 1924. Rapp. et Proc.-Verb., LVI, 1—29, 1929.

Oelbuch, H. Die Eisverhältnisse an den deutschen Küsten in Memel und Danzig während des Winters 1928—29. Ann. der Hydrog. und Marit. Met., LVII, 192—93, 1929.

Rabot, Ch. Arrivée anormale d'icebergs sur la côte nord de la Norvège. C. R. Acad. Sci. Paris, CLXXXVIII, 1563—65, 1929.

Ramalho, A. et Dentinho, L. Remarques sur les conditions océanographiques au large de la côte de Portugal. (1927). Rapp. et Proc.-Verb., LV, 111—32, 1929.

Schulz, B. Hydrographie des westlichen Barentsmeeres a. Grund der i. d. Sommern 1926 und 1927 gewonnenen Beobachtungen. Dr. A. Petermann's Geog. Mitt. Ergänz. H. 201, 1929.

Speerschneider, C. I. H. Isforholdene i de Arktiske Have (The State of the Ice in the Arctic Seas) 1928. Nautisk Meteorologisk Aarbog 1927. Copenhagen. 1928.

Tait, J. B. Hydrographical Survey of the Moray Firth. Rapp. et Proc.-Verb., LII, 48—75, 1928.

Physics and Chemistry of Sea Water.

Kolkwitz, R. Das Thermoplanktometer. Ber. Deutsch. Botan. Gesell., XLVII 64—67, 1929.

TEMPERATURE AND SALINITY

Brooks, C. F. Reliability of Different Methods of Taking Sea Surface Temperature. Journ. Wash. Acad. Sci. XVIII, 525—45, 1928.

Chipman, H. R. Fundamental Principles of Chemistry and Physics. Biol. Board of Canada. Bull. No. XI, 1928.

Demel, K. Température des eaux côtières de la Baltique et Résultats des pêches maritimes de la Pologne en 1927. Arch. d'Hydrobiol. et d'Ichth. III, 123—31, 1928. (In Polish).

Lipman, C. B. The Chemical Composition of Sea Water. Papers from the Tortugas Lab. of Carnegie Inst. of Washington. XXVI, 249—57, 1929.

Mäe, H. Über den Wärmeaustausch zwischen Luft und Wasser. Ann. der Hydrog. und Marit. Met. LVII, 53—58, 1929.

McEwen, G. F. Significance of Water-Temperature Measurements not made exactly at the Surface. Journ. Wash. Acad. Sci. XVIII, 545—46, 1928.

Moniak, J. Variations de la température dans la région de l'Atlantique N. durant les années 1910 à 1919. Commun. Inst. de Geophys. etc. Univ. Lvow, III, 31—42, 1928.

Page, I. H. Further Observations on the Chemical Composition of Woods Hole Sea Water — The Chlorine Content and Salt Analysis. Biol. Bull. of the Mar. Biol. Lab., Woods Hole, Mass. LV, 449—52, 1928.

Richard, J. Sur un procédé simple pour extraire l'eau douce de l'eau de mer, des eaux salées ou polluées, de toutes les substances aqueuses et même de l'atmosphère, au moyen de la chaleur solaire. Bull. de l'Inst. Océan. No. 535, Monaco. 1929.

Seilkopf, H. Täglicher Gang der Aufstellungsfehler bei Temperaturmessungen auf Schiffen. Ann. der Hydrog. und Marit. Met. LVII, 108—13, 1929.

Van Riel, P. M. The Influence of sea disturbance on surface temperature. Meded. en Verhand. 30, Kon. Nederlandsch Meteor. Inst. 103, Amsterdam. 1928.

Van Riel, P. M. Oberflächensalzgehalt im südlichen Teil der Nordsee. (Monatskarten, Monats- und Dekaden-Abweichungen). Journ. du Cons. IV, 43—67, 1929.

HYDROGEN ION CONCENTRATION AND DISSOLVED GASES

Margaria, R. La riserva alcalina dell'acqua di mare. Rendiconti R. Accad. Lincei, (Sci. Fis.) IX. Roma, 816—20, 1929.

Wattenberg, H. Die Durchlüftung des Atlantischen Ozeans, (Vorläufige Mitteilung aus den Ergebnissen der Deutschen Atlantischen Expedition). Journ. du Cons. IV, 68—79, 1929.

PHOSPHATES AND NITRATES

Brandt, K. Phosphate- und Stickstoffverbindungen als Minimumstoffe für die Produktion im Meere (English Summary). Rapp. et Proc.-Verb., LIII, 5—35, 1929.

Buch, K. Über die Bestimmungen von Stickstoffverbindungen und Phosphaten im Meerwasser (English Summary). Rapp. et Proc.-Verb., LIII, 36—52, 1929.

Giral, J. Quelques observations aux thèmes: Méthodes pour l'étude des phosphates et les matières azotées dans l'eau de mer. Rapp. et Proc.-Verb., LIII, 53—67, 1929.

Harvey, H. W. Methods of Estimating Phosphates and Nitrates in Sea Water. Rapp. et Proc.-Verb., LIII, 68—74, 1929.

International Council. Concerning Methods for Estimating Phosphates and Nitrates in Solution in Sea Water. (Reports on the Results of the Special Investigation conducted at the Univ. of Oslo in Oct. 1928). Rapp. et Proc.-Verb., LIII, 95—115, 1929.

Nardo, L. V. de. Une nouvelle méthode de dosage colorimétrique des nitrates dans les sols et les eaux. C. R. Acad. Sci. Paris, CLXXXVIII, 563—65, 1929.

Schreiber, E. Die Methoden einer physiologischen Meerwasseranalyse. (English Summary). Rapp. et Proc.-Verb., LIII, 75—79, 1929.

Sund, O. The Determination of Nitrates in Sea Water. Rapp. et Proc.-Verb., LIII, 80—89, 1929.

Wattenberg, H. Die Phosphat- und Nitrat-Untersuchungen der Deutschen Atlantischen Expedition auf V.S. "Meteor". (English Summary). Rapp. et Proc.-Verb., LIII, 90—94, 1929.

OTHER CONSTITUENTS

Knapp, E. M. The Precipitation of Calcium and Magnesium from Sea Water by Sodium Hydroxide. Biol. Bull. of the Mar. Biol. Lab. Woods Hole. Mass., LV, 453—58, 1928.

Currents.

Anon. The apparatus of Alfred Merz for measuring strong and weak current flow. Hydrog. Review. VI, 157—62, 1929.

Becker, R. Über oszillierende Bewegungen einer Luftmasse unter dem Einfluss der Erdbodenreibung. Met. Zeitschr. H. 2, 1929.

Breitfuss, L. Erläuternder Text mit 1 Deckblatt zur Karte von F. Nansen. Arktis H. 1, 1929.

Defant, A. Stabile Lagerung ozeanischer Wasserkörper und dazu gehörige Stromsysteme. Veröff. des Inst. für Meereskunde. N. F. A. Geogr. Reihe, Hefte 19, 1929.

Harvey, H. W. Hydrodynamics of the Waters South East of Ireland. Journ. du Cons. IV, 80—92, 1929.

Hessen, K. Karten der Strömungen in der Nähe von Helgoland. Marine-Observationen, K. Hessen, Wilhelmshaven. 1929.

Idrac, P. Sur quelques singularités du Gulf-Stream. C. R. Acad. Sci. Paris, CLXXXVIII, 644—46, 1929.

Lasareff, P. Sur une méthode permettant de démontrer la dépendance de courants océaniques des vents alizés et sur le rôle de courants océaniques dans le changement du climat aux époques géologiques. Gerlands Beitr. z. Geophys. XXI, H. 2-3, 1929.

Lundbeck, J. Studien über das Frische Haff. III. Die Strömungen und ihre Beziehungen zu Wasserhaushalt und Wasserbeschaffenheit im Frischen Haff. Schriften der Phys-ökon. Gesells. zu Königsberg i. Pr. LXV, Heft 3—4, 1928.

Maukisch, W. Die Meeresströmungen von 5° N. Br. bis 35° S. Br. zwischen 10° W. Lg. u. dem westafrikan Festland. Pilote, H. 29, 1929.

Nansen, F. Karten der Höhen, Tiefen und Strömungen im Nordpolarbecken. Arktis. H. I, 1929.

Rauschelbach, H. Beschreibung eines bifilar aufgehängten, an Bord elektrisch registrierenden Strommessers. Deutsche Seewarte. Beiheft zu den Annal. der Hydrog. und Marit. Met., 1929.

Schott, G. Die Wasserbewegungen in dem Gebiete der Gibraltarstrasse. Rapp. et Proc.-Verb., LV, 133—38, 1929.

Thoulet, J. Le courant Kuriosio du Japon. C. R. Acad. Sci. Paris, CLXXXVIII, 873—74, 1929.

Wüst, G. Schichtung und Tiefenzirkulation des Pazifischen Ozeans. Veröff. des Inst. für Meereskunde. N. F. A. Geogr. Reihe, Heft 20, 1929.

TIDES

Anon. Atlas über die Gezeitenströmungen im östl. Teile des Weissen Meeres. Hydrogr. Verwaltg. Leningrad. 1929.

Bencker, H. A Study of the Tide Tables published by the different Nations. Hydrogr. Review, VI, 127—50, 1929.

Goldsbrough, G. R. The Tides in Oceans on a rotating globe. Proc. R. Soc. London. A. CXXII, No. 789, 1929.

Mallock, A. Rise and Fall of the Tides. Nature CXXIII, 640—41, 1929.

Thorade, H. Beiträge zur Theorie der Gezeitströme. Gerlands Beitr. zur Geophysik. XXI, Heft 2—3, 290—312, 1929.

Thorade, H. Gezeitenuntersuchungen in der Deutschen Bucht der Nordsee. "Panther" Beobacht. 1924. Arch. d. Deutschen Seewarte. XLVI, No. 3, 1929.

WIND

LITTLEHALES, G. W. The Effect of Surface-Winds upon Ocean Drift. Journ. Wash. Acad. Sci. XVIII, 548—49, 1928.

WILLER, A. Wind und Fischwasser. Arb. aus dem Fisch. Inst. der Univ. Königsberg. Pr. No. 41, 1929.

LIGHT, COLOUR, AND TRANSPARENCY

POOLE, H. H. and ATKINS, W. R. G. Photo-electric Measurements of Submarine Illumination throughout the Year. Journ. Mar. Biol. Assoc. XVI, 297—324, 1929.

KIMBALL, H. H. Amount of solar radiation that reaches the surfaces of the earth on the land and on the sea, and methods by which it is measured. Monthly Weather Review. U.S.A. Dept. Agric. Oct. 1928.

Oceanography — Miscellaneous.

CHARCOT, J. A la recherche du "*Latham 47*". Bull. de la Soc. d'Océan. de France. IX, 865—75, 1929.

PETTERSSON, O. Changes in the Oceanic Circulation and their Climatic Consequences. Geogr. Review, New York. 121—31, Jan. 1929.

PRATJE, O. Wie sieht der Boden des Südatlantischen Ozeans aus? Natur und Museum. Heft 10, Frankfurt. 1928.

SUND, O. An Oceanographical Slide Rule. A new apparatus for calculating oceanographical data. Journ. du Cons. IV, 93—98, 1929.

THORADE, H. Vorläufige Ergebnisse der Deutschen Atlantischen Expedition auf "Meteor". Dr. A. Petermanns Geogr. Mitt. LXXV, 65—69, 1929.

VALLAUX, C. La Classification des océans et des mers. La Géographie. L. No. 3—4, 1928.

Plankton.

CANDEIAS, A. Première Liste des Copépodes des côtes du Portugal. Rapp. et Proc.-Verb. LV, 151—52, 1929.

CANNON, H. GRAHAM. On the Feeding Mechanism of the Copepods *Calanus finmarchicus* and *Diaptomus gracilis*. Brit. Journ. Exper. Biol. VI, 131—44, 1928.

CARTER, G. S. On the Structure of the Cells bearing the Velar Cilia of the Nudibranch Veliger. Brit. Journ. of Exper. Biol. VI, 97—109, 1928.

GRAN, H. H. Investigation of the Production of Plankton outside the Romsdalsfjord. 1926—27. Rapp. et Proc.-Verb. LVI, 1—112, 1929.

GRAN, H. H. Quantitative Plankton Investigations carried out during the Expedition with the "Michael Sars" July—Sept. 1924. Rapp. et Proc.-Verb. LVI, 1—50, 1929.

GURJANOWA, E. Neue Formen arktischer Isopoden und Amphipoden. Zool. Anz. LXXXI, 309—17, 1929.

GURJANOVA, E. F. Contribution to the fauna of Amphipoda in the Barents Sea. Trans. of the Northern Scien. and Econ. Exp. No. 37, 43—54. (U. S. S. R. Scien. — Tech. Dept. No. 199) Moscow. 1928. (In Russian, English Résumé).

JORGENSEN, O. M. The Plankton of the River Tyne Estuary. Proc. Univ. of Durham Phil. Soc. VIII, 41—54, 1929.

KISSELEV, J. A. Contribution to the question of distribution and composition of the phytoplankton in the Barents Sea. Trans. of the Northern Scient. and Econ. Exp. No. 37, 28—42, (U. S. S. R. Scien. — Tech. Dept. No. 199). Moscow. 1928. (In Russian, English Résumé).

NIKITINE, B. Les migrations verticales saisonnières des organismes planktoniques dans la Mer Noire. Bull. de l'Inst. Océan. No. 540. Monaco. 1929.

PAULSEN, O. Notas generales sobre el Microplancton. Bol. de Pescas, XIII, 325—42, 1928.

RUUD, J. T. On the Biology of Copepods off Møre 1925—27, Rapp. et Proc.-Verb., LVI, 1—84, 1929.

SEIWELL, H. R. Patterns of Conical Silk Plankton Nets of one Meter and Half-Meter Diameters. Journ. du Cons. IV, 99—103, 1929.

STEPHENSEN, K. Amphipoda. Die Tierwelt der Nord- und Ostsee. (Grimpe u. Wagler). Teil X. F, 1929.

Störmer, Leif. Copepods from the "Michael Sars" Expedition 1924. Rapp. et Proc.-Verb. LVI, 1—57, 1929.

Wilson, D. P. The Larvae of the British Sabellarians. Journ. Mar. Biol. Assoc. XVI, 221—70, 1929.

Wirketis, M. A. Some evidence on the Zooplankton in the Barents Sea, along the Kola-Meridian. Trans. of the Northern Scien. and Econ. Exp. No. 37, 6—27, (U. S. S. R. Scien.-Tech. Dept. No. 199), Moscow, 1928. (In Russian, English Résumé).

MARINE BACTERIA

Lipman, C. B. Further Studies on Marine Bacteria with Special Reference to the Drew Hypothesis on $CaCO_3$ Precipitation in the Sea. Papers from the Tortugas Lab. of Carnegie Inst. of Washington. XXVI, 231—48, 1929.

MARINE ALGAE

Dostal, R. *Caulerpa Ollivieri* n. sp. la seconde espèce européenne des Caulerpacées. Bull. de l'Inst. Océan. No. 531, Monaco. 1929.

Bottom Deposits.

Bowman, A. The Moray Firth. Physical Characteristics. Rapp. et Proc.-Verb., LII, 39—42, 1928.

Bréon, R. Observations sur les dépôts littoraux. C. R. Acad. Sci. Paris, CLXXXVIII, 926—27, 1929.

Dangeard, L. Observations de Géologie sous-marine et d'océanographie relatives à la Manche. Ann. de l'Inst. Océan. VI, 1—295, 1928.

Bottom Fauna.

GENERAL

Blegvad, H. Quantitative Investigations of Bottom Invertebrates in the Limfjord. 1910—27, with special reference to the Plaice Food. Rep. Danish Biol. Stat. XXXIV, 33—52, 1928.

Spärck, R. Preliminary Survey of the Results of Quantitative Bottom Investigations in Iceland and Faröe Waters, 1926—27. Rapp. et Proc.-Verb., LVII, 1929.

Stephen, A. C. The Bottom Fauna of the Moray Firth. — Investigations with the Petersen Bottom Sampler. Rapp. et Proc. Verb., LII, 43—47, 1928.

Stephen, A. C. Notes on the Quantitative Distribution of Molluscs and Polychaetes in Certain Intertidal Areas on the Scottish Coast. Proc. Roy. Physical Soc. Edinburgh, XXI, 205—16, 1928.

SPECIAL GROUPS

Allgén, C. Was ist die von Bütschli 1874 aufgestellte *Odontophora marina*? Zool. Anz. LXXXI, 305—09, 1929.

Boschma, H. *Galatheacus striatus* a New Rhizocephalan. Journ. Mar. Biol. Assoc. XVI, 73—80, 1929.

Carlgren, O. Über eine Actiniariengattung mit besonderen Fangtentakeln. Zool. Anz. LXXXI, 109—13, 1929.

Elmhirst, R. and Stephen, A. C. Local extinction of a Recently Abundant Lamellibranch. Nature CXXIII, 606, 1929.

Hertling, H. Mitteilung über *Ommatostrephes sagittatus* und *Loligo vulgaris* in der Nordsee. Zool. Anz. LXXX, 319—23, 1929.

Lacroix, D. *Textularia sagittula* ou *Spiroplicta Wrightii*? Bull. de l'Inst. Océan. No. 532. Monaco. 1929.

Manton, S. M. On some Points in the Anatomy and Habits of the Lophogastrid Crustacea. Trans. Roy. Soc. Edinburgh. LVI, 103—20, 1929.

Okada, Y. K. Sacconereis of *Procerastea*. Journ. Mar. Biol. Assoc. XVI, 325—28, 1929.

Orton, J. H. On the Occurrence of *Echinus esculentus* on the Foreshore in the British Isles. Journ. Mar. Biol. Assoc. XVI, 289—98, 1929.

Orton, J. H. Observations on *Patella vulgata*. Pt. III. Habitat and Habits. Journ. Mar. Biol. Assoc. XVI, 277—88, 1929.

Percival, E. A Report on the Fauna of the Estuaries of the River Tamar and the River Lynher. Journ. Mar. Biol. Assoc. XVI, 81—108, 1929.

Rathbun, M. J. Canadian Atlantic Fauna. 10. Arthropoda 10. Decapoda. Biol. Board of Canada. Atlantic Biol. Stat., 1929.

Remane, A. *Proales gonothyraeae* n. sp. ein an Hydroidpolypen parasitierendes Radertier. Zool. Anz. LXXX, 289—95, 1929.

Reid, D. M. On some Factors limiting the Habitat of *Arenicola marina*. Journ. Mar. Biol. Assoc. XVI, 109—16, 1929.

Rezvoj, P. O. Contribution to the fauna of Porifera in the Barents Sea. Trans. of the Northern Scien. and Econ. Exp. No. 37, 67—95, (U. S. S. R. Scien. — Tech. Dept. No. 199), Moscow, 1928. (In Russian, English Résumé.)

Robson, G. C. Notes on the Cephalopoda VIII. The Genera and Subgenera of *Octopodina* and *Bathypolypodina*. IX. Remarks on Atlantic Octopoda etc. in the Zoologisch Museum, Amsterdam. Ann. & Mag. of Nat. Hist. 10 Ser. III, 607—18, 1929.

Sasaki, M. A Monograph of the Dibranchiate Cephalopods of the Japanese and Adjacent Waters. Journ. Fac. of Agric. Hokkaido. Imp. Univ. Sapporo. Japan, XX, Supp. Number. 1929.

Stephen, A. C. Notes on the Rate of Growth of *Tellina tenuis* Da Costa in the Firth of Clyde. Journ. Mar. Biol. Assoc. XVI, 117—30, 1929.

Stephenson, T. A. On the Methods of Reproduction as Specific Characters in Sea Anemones. Journ. Mar. Biol. Assoc. XVI, 131—72, 1929.

Stephenson, T. A. On the Nematocysts of Sea Anemones. Journ. Mar. Biol. Assoc. XVI, 173—202, 1929.

Stephenson, T. A. A Contribution to Actinian Morphology. The Genera *Phellia* and *Sagartia*. Trans. Roy. Soc. Edinburgh, LVI, 121—40, 1929.

Topsent, E. Notes sur *Helophoeina Stylivanrians* n. g. n. sp., Mycaline à desmes des Canaries. Bull. de l'Inst. Océan. No. 533. Monaco, 1929.

Topsent, E. *Spongionella* Bow. et *Cacospongia* Schm. Bull. de l'Inst. Océan. No. 537, Monaco. 1929.

Uschakow, P. W. Contribution to the fauna of Nemerteans in the Barents Sea. Trans. of the Northern Scien. and Econ. Exp. No. 37, 55—66 (U. S. S. R. Scien.-Tech. Dept. No. 199). Moscow, 1928. (In Russian, English Résumé.)

Watson, A. T. Observations on the Habits and Life History of *Pectinaria* (*Lagis*) *koreni* Mgr. Proc. and Trans. of the Liverpool Biol. Soc. XLII, 25—60, 1928.

Fishery Investigations.

GENERAL

Belloc, C. La croisière de la "Tanche" (Août 1927) Rapp. Atlant. 1927. Rapp. et Proc.-Verb., LV, 139—50, 1929.

Bjerkan, P. On the Validity of the "Race Characters" of the Food Fishes. Rapp. et Proc.-Verb., LIV, 73—77, 1929.

Bowman, A. Line Fishing in the Moray Firth during the period 1904—16. (Inclusive.) Rapp. et Proc.-Verb., LII, 86—149, 1928.

Bowman, A. Danish Seine Net-Fishing in the Moray Firth. Rapp. et Proc.-Verb., LII, 179—216, 1928.

Bowman, A. Occurrences of Non-British Trawlers in the Moray Firth. Rapp. et Proc.-Verb., LII, 217—25, 1928.

Brunelli, G. Untersuchungen über die Rassen der Nutzfische. (English Summary). Rapp. et Proc.-Verb., LIV, 17—20, 1929.

Crowe, H. J. The Closure of the Moray Firth to Trawling. A Historical Account of the Problem with a general Survey of the Fisheries of the Firth. Rapp. et Proc.-Verb., LII, 1—38, 1928.

Demel, K. Les périodes des pêches minimales dans les eaux polonaises de la Baltique. Przegladu. N. D.

Fischer, E. Recherches de Bionomie et d'Océanographie littorales sur la Rance et le littoral de la Manche. Ann. de l'Inst. Océan. V, 203—429, Monaco 1929.

Graham, M. On Methods of Marking Round Fish with an Account of Tests in Aquaria. Fish. Invest. Ser. II. XI, No. 4, 1929.

Higgins, E. Progress in Biological Inquiries. App. VI to the Rep. of the U. S. Com. of Fish. for 1928, 199—247, 1928.

International Council. Report of the Committee appointed by the Council to consider the question of the Closure of the Moray Firth to Trawling. Rapp. et Proc.-Verb., LII, 1928.

International Council. Rapport Atlantique 1927. Rapp. et Proc.-Verb., LV, 1929.

Knipovitch, N. M. Trawling Works of the Northern Scientific and Economic Expedition in the Polar Ocean in 1920—21. Trans of the Northern Scien. and Econ. Exp. No. 23, (U. S. S. R. Scien.-Tech. Dept. No. 89). Moscow, 1925. (In Russian, English Résumé.)

Rosén, N. En tång for märkning av fisk. Ny Svensk Fiskeritidskr. 55, 1929.

Thompson, d'Arcy W. Note. Apparatus for Measuring Fish. Journ. du Cons. IV, 104, 1929.

EGGS AND LARVAE

Hata, K. On the Influence of the Duration of Time of Vibration upon Development of Fish Eggs. Journ. of the Imp. Fish. Inst. XXIV, 121—23, Tokyo, 1929.

FOOD OF FISH

Hertling, H. Die Nahrung der Ostseefische. Mitt. Deutsch. Seefisch. Ver. XXXXV, 101—22, 1929.

AGE DETERMINATION

Avrutina, E. V. On the question of the methods of age and growth-rate determination in fishes (in connection with the investigation of *Rutilus rutilus lacustris* Pallas from the Barabinsky Lakes). Rep. of the Siberian Sci. Stat. Fish. III, No. 3, 105—60, 1929. (In Russian, English Résumé).

Graham, M. Studies in Age-Determination of Fish. Part II. A Survey of the Literature. Fish. Invest. Ser. II, XI, No. 3, 1929.

van Oosten, J. Life History of the Lake Herring (*Leucichthys artedi* le Sueur) of Lake Huron as revealed by its scales, with a critique of the Scale Method. Bull. Bur. of Fish. U.S.A. XLIV, 267—428, 1929.

COMMERCIAL FISHERIES

Anon. Der Tunfischfang in Norwegen. Mitt. Deutsch. Seefisch. Ver., XXXXV, 74—75, 1929.

Anon. Exploring the Faröe Ridge. Fish Trades Gazette. 16, May 25th, 1929.

Beaugé, L. Rapport de Mission sur le Banc de Terre-Neuve (Campagne 1927), 2e partie. Rev. des Trav. de l'Office des Pêches Mar. I, Fasc. 3, 5—35, 1928.

England. Fisheries — England and Wales. Sea Fisheries. Statistical Tables, 1928. Ministry of Agriculture and Fisheries. H.M.S.O. 1929.

Henking, H. Die Ostseefischerei. Handb. der Seefisch. Nordeuropas. (Lübbert und Ehrenbaum.) V, H. 3, Stuttgart, 1929.

Kyle, H. M. Die Seefischerei von Grossbrittannien und Irland. Handb. der Seefisch. Nordeuropas. (Lübbert und Ehrenbaum.) VI, H. 1—4, Stuttgart, 1929.

Norway. Beretninger om torskefisket (utenom Lofoten) og silde-, makrell- og bankfisket samt selfangsten i 1927. Årsberet. vedkom. Norges Fisk. 1927, No. XII, 1928.

Scotland. Sea Fisheries. Statistical Tables 1928. Fishery Board for Scotland. 1929.

Steinert, H. Die Entwicklung der polnischen Seefischerei. Der Fischerbote XXI, 107—10, 1929.

Strand, A. Lofotfisket 1928. Årsberet. vedkom. Norges Fisk. 1928. No. VII, 1929.

Willer, A. Ostpreussen, Lettland, Finnland, eine fischereiliche Betrachtung. Mitt. d. Deutsch. Seefisch. Ver. XXXXV, 157—81, 1929.

FISHING GEAR

Bowman, A. General Considerations. The Qualitative effect of different Fishing Gears on the stock of the Marketable Species. Rapp. et Proc.-Verb., LII, 6—38, 1928.

Lissner, H. und Fisk, H. Zur Technik der Schernetzfischerei. Der Fischerbote XXI, 166—67, 1929.

Fishes.

GENERAL

Berrill, N. J. The validity of *Lophius americanus* Val. as a species distinct from *L. piscatorius* Linn. with notes on the rate of development. Cont. to Canadian Biol. and Fish. N. S. IV, 143—55, 1929.

Bowman, A. Fish of the Moray Firth. Rapp. et Proc.-Verb., LII, 58—69, 1928.

Cowan, D. Spawning of the Lumpsucker. Rep. Dove Mar. Lab. for year ending June 30th, 1928, 37—38, 1929.

Esipov, W. K. The question of the relation between the body length of the fish and its weight. Rep. of the Siberian Sci. Stat. of Fish., III, No. 3, 161—76, 1929. (In Russian.)

Fontaine, M. De l'augmentation de la consommation d'oxygène des animaux marins sous l'influence des forts pressions. C. R. Acad. Sci. Paris, CLXXXVIII, 460—61, 662—63, 1929.

Knipovitch, N. M. Guide for Determination of the Fishes of Barents Sea, White Sea, and Kara Sea. Trans. of the Northern Scien. and Econ. Exp. No. 27. (U. S. S. R. Schien.-Tech. Dept. No. 103.) Moscow 1926. (In Russian.)

Knipovitch, N. M. Tables for Determination of Marine and Migratory Fishes of the European Glacial Ocean and the White and Kara Sea. Trans. of the Northern Scien. and Econ. Exp. No. 31. (U. S. S. R. Scien.-Tech. Dept. No. 144.) Moscow. 1926. (In Russian.)

Landreyt, F. Sur un odontome cutané chez un *Scyllium catulus* Cuv. Bull. de l'Inst. Océan. No. 539, Monaco. 1929.

Lozano y Rey. Fauna Iberica. Pesces (Fishes). Museo Nacional dé Ciencias Naturales. Madrid. 1928.

Magnan, A. Les caractéristiques géométriques et physiques des Poissons avec contribution à l'étude de leur équilibre statique et dynamique. Ann. des Sci. Naturelles. Zool. Xe. Ser. XII, 5—133, 1929.

Mannsfeld, W. Der Schwertfisch (*Xiphias gladius* L.) an der lettländischen Ostseeküste. Mitt. Deutsch. Seefisch. Ver. XXXXIV, 356—58, 1928.

Norman, J. R. Note on a Sailfish *Istiophorus americanus* Cuvier and Valenciennes, new to the British Fauna. Journ. Mar. Biol. Assoc. XVI, 67—72, 1929.

Odada, M. Note on Leading the Movement of Fish-Groups by Electric Current. Journ. of the Imp. Fish. Inst. XXIV, 124—28, 1929. Tokyo.

Regan, C. Tate and Trewavas, E. The Fishes of the Families *Astronesthidae* and *Chauliodontidae*. The Danish Dana Exped. 1920—22 in the North Atlantic and the Gulf of Panama. Ocean. Rep. ed. by the Dana Com. No. 5, Copenhagen. 1929.

Rode, P. Recherches sur l'Organe sensoriel latéral des Téléostéens. Bull. Biol. France Belgique. LXIII, 2—84, 1929.

Roule, L. Les Poissons et le Monde vivant des Eaux. III. Voyages et Migrations. Paris, 1929.

Schnoor, H. Vernichtung von Nutzfischen der Ostsee durch den strengen Winter. Mitt. Deutsch. Seefisch. Ver., XXXXV, 174, 1929.

Stephen, A. C. Notes on Silver Smelts (*Argentina*) landed at Newhaven. Scottish Naturalist. 24—25, 1929.

PLAICE

Anon. Die Schollenfischerei im Barents Meer. Der Fischerbote XXI, 183—90, 1929.

Awerinzew, S. Über *Pleuronectes platessa* des Barents-Meeres. I. Zool. Anz. LXXX, 149—58, 1929.

Brühl, L. Die Schollenerbrütungsanlage in der Biologischen Station zu Trondhjem. Mitt. Deutsch. Seefisch. Ver. XXXXIV, 578—89, 1928.

Jensen, A. J. C. The Relation between the Size of the Plaice Stock and the Quantity of "First Class Plaice Food" in certain parts of the Limfjord. Rep. Dansk Biol. Stat. XXXIV, 87—98, 1928.

Johansen, A. C. Om Resultatet af den foretagne Indplantning af Rødspætter til vore indre Farvande i Foraaret 1928. Dansk Fiskerit. No. 3, 1929.

Johansen, A. C. The Extent of the Annual Transplantations of Plaice in the Limfjord and the Yield resulting therefrom. Rep. Danish Biol. Stat. XXXIV, 53—86, 1928.

JOHANSEN, A. C. On some characters of the Baltic Plaice which have changed during the last decennaries. Rapp. et Proc.-Verb., LIV, 78—98, 1929.
TÅNING, Å. V. Plaice Investigations in Icelandic Waters. Rapp. et Proc.-Verb., LVII, 1929.
WALLER, J. Rodspætteomplantningen, 1928. Dansk Fiskerit. No. 4, 1929.

OTHER PLEURONECTIDAE

SCOTT, W. C. M. A Note on the effect of temperature and salinity on the hatching of the eggs of the winter flounder (*Pseudopleuronectes americanus* Walbaum). Contr. to Canadian Biol. and Fish. N. S. IV, 137—41, 1929.
SUVOROV, E. The Biology of *Pleuronectes flesus* of the Murman Coast. Trans. of the Northern Scien. and Econ. Exp. No. 38, 56—63. (U. S. S. R. Scien.-Tech. Dept. No. 205.) Moscow, 1927. (In Russian, German Résumé.)

COD

ANON. Frågan om minimimått a gadda, gös och kräfta. Ny Svensk Fiskeritidskr. 16—17, 22—23. 1929.
BLICH, J. W. Norges tørrfiskeksport i tiden 1890—1928 statistisk belyst med kort historisk oversikt. Årsberet. vedkom. Norges Fiskerier 1928. Nr. IX, 1929.
BOWMAN, A. Review of the Cod Net Fishing in the Moray Firth. Rapp. et Proc.-Verb., LII, 150—78, 1928.
FRIDRIKSSON, A. Age-Composition of the Stock of Cod in East Iceland Fjords during the years 1925—27. Rapp. et Proc.-Verb., LVII, 1929.
GRAHAM, M. Studies in Age-Determination in Fish. Part I. A Study of the growth rate of the Codling (*Gadus callarias* L.) on the Inner Herring Trawling Ground. With a Section on the Relevant Hydrography by J. R. Lumby. Fish. Invns. Ser. II. XI, No. 2, 1929.
SUVOROV, E. Ichthyological Investigations at the Murman Coast in the summer 1921 (Age-determinations in Cod and Haddock). Trans. of the Northern Scien. & Econ. Exp. No. 38, 44—55. (U. S. S. R. Scien-Tech. Dept. No. 205.) Moscow, 1927. (In Russian, German Résumé.)
SCHMIDT, J. Racial Investigations. Rapp. et Proc.-Verb., LIV, 72, 1929.

HADDOCK

ANDERSSON, K. A. Kolfefisket i Skagerak och utsikterna för det samma under den närmaste framtiden. Ny Svensk Fiskeritidskr. 17—23, 1929.
NEEDLER, A. W. H. Studies on the Life History of the Haddock (*Melanogrammus aeglifinus* Linnaeus). Contr. to Canadian Biol. and Fish. N. S. IV, 265—85, 1929.
POULSEN, E. M. The Haddock in the Belt Sea and the Western Baltic during the years 1926—28. Rep. Danish Biol. Stat. XXXIV, 99—125, 1928.
SUVOROV, E. Ichthyological Investigations at the Murman Coast in the summer 1921 (Age-determinations of Cod and Haddock). Trans. of the Northern Scien. and Econ. Exp. No. 38, 44—55. (U. S. S. R. Scien-Tech. Dept. No. 205.) Moscow. 1927. (In Russian, German Résumé.)
THOMPSON, H. The Haddock of the North Western North Sea. Rapp. et Proc.-Verb., LII, 70—85, 1928.
THOMPSON, H. Haddock Biology (North Sea). Rapp. et Proc.-Verb., LIV, 135—63, 1929.
THOMPSON, H. General features in the Biology of the Haddock (*Gadus aeglefinus* L.) in Icelandic Waters in the Period 1903—1926. Rapp. et Proc.-Verb., LVII, 1929.

HAKE

HICKLING, C. F. Résumé de "The Natural History of the Hake". Pts. I & II. Rapp. et Proc.-Verb., LV, 153—54, 1929.

TUNNY

SANZO, L. Uova e larve di tonno, *Orcynus thynnus*. Rendiconti R. Accad. Lincei, (Sci. Fis.) IX, Roma, 816—20, 1929.

HERRING

Averinzev, S. Herrings of the White Sea. Parts II & III. Abdh. des Wiss. Instit. für Fischwirts. III. Heft 4, 72—112, 1929. Moscow 1928. (In Russian.)

Cowan, D. Herring Investigations. 2. Size. Rep. Dove Mar. Lab. for year ending June 30th, 1928. 32—36, 1929.

Ehrenbaum, E. Rassenuntersuchungen an Nutzfischen, besonders am Hering. (English Summary.) Rapp. et Proc.-Verb., LIV, 5—16, 1929.

Ford, E. Herring Investigations at Plymouth. V. The Plymouth Winter Fishery during the Season 1927—28. Journ. Mar. Biol. Assoc. XVI, 1—24, 1929.

Ford, E. Herring Investigations at Plymouth. VI. Winter Herrings caught off the Sussex Coast and in the Great West Bay during the years 1924—27. Journ. Mar. Biol. Assoc. XVI, 25—42, 1929.

Ford, E. Herring Investigations at Plymouth. VII. On the Artificial Fertilisation and Hatching of Herring Eggs under known Conditions of Salinity, with some Observations on the Specific Gravity of the Larvae. Journ. Mar. Biol. Assoc. XVI, 43—48, 1929.

Holland. Rapport der Commissie voor de Haringvisscherij. S. Gravenhage. 1929.

Lea, E. The Herring's Scale as a Certificate of Origin. Its Applicability to Race Investigations. Rapp. et Proc.-Verb., LIV, 21—34, 1929.

Lea, E. The Oceanic Stage of the Life History of the Norwegian Herring. Journ. du Cons. IV, 3—42, 1929.

Mielck, W. Die Verbreitung der Heringslarven in der Nordsee im Winter. Rapp. et Proc.-Verb., LIV, 99—134, 1929. (English Summary.)

Rabinerson, A. Contributions to the Natural History of the White Sea Herring. Trans. of the Northern Scien. and Econ. Exp. No. 25. (U. S. S. R. Scien.-Tech. Dept. No. 91.) Moscow 1925. (In Russian, English Résumé.)

Rabinerson, A. Investigations on the herring of the White Sea and the Murman Coast. Trans. of the Northern Scien. and Econ. Exp. No. 38, 64—78. (U. S. S. R. Scien.-Tech. Dept. No. 205.) Moscow. 1927. (In Russian, German Résumé.)

Schnakenbeck, W. Der isländische Versuch mit Flugzeugen Heringsschwärme aufzusuchen. Der Fischerbote XXI, 134—36, 1929.

Skwortzoff, I. N. Zur Technik des Fanges des Weissmeerherings. Abdh. des Wiss. Instit. für Fischwirts. III. Heft 4, 1—70, 1929. Moscow. 1928. (In Russian.)

Storrow, B. Herring Investigations. I. Herring Shoals. Rep. Dove Mar. Lab. for year ending June 30th, 1928. 9—31, 1929.

Tesch, J. J. Investigations on Herring in the Southern North Sea. Rapp. et Proc.-Verb., LIV, 56—71, 1929.

Wynne-Edwards V. C. The Reproductive Organs of the Herring in Relation to Growth. Journ. Mar. Biol. Assoc. XVI, 49—66, 1929.

PILCHARD, SPRAT, ANCHOVY

de Buen, F. Études des Sardines des Côtes d'Espagne. Rapp. et Proc.-Verb., LIV, 42—45, 1929.

le Danois, E. Les races locales de la Sardine des Côtes françaises (Manche et Atlantique). Rapp. et Proc.-Verb., LIV, 35—41, 1929.

le Gall, J. Contribution à l'étude de la sardine des côtes françaises de la Manche et de l'Atlantique. Rev. des Trav. de l'Office des Pêches Mar. I. Fasc. 2, 11—26, 1928.

Lebour, M. V. The Food of *Sardina pilchardus* (Walbaum). Bull. Soc. d. Sci. Nat. du Maroc. VII, 220—23, 1927.

Ramalho, A. Contribution à l'étude des races de la Sardine (*Sardina pilchardus* Walb.) au Portugal, à Madeira et aux Açores. Rapp. et Proc.-Verb., LIV, 46—55, 1929.

MACKEREL

Anon. Prévisions concernant le rendement de la pêche du maquereau. La Pêche Maritime. 164, 1929.

EELS

Anon. Der Bezug englischer Aalbrut im Jahre 1929. Der Fischerbote XXI, 182—83, 1929.

Hornyold, A. Gandolfi. Observations sur la taille et le sexe de la petite Anguille

argentée de l'Étang de Thau en 1927—28. Bull. de la Soc. d'Océan. de France. IX, 876—79, 1929.

HORNYOLD, A. GANDOLFI. Sur la possibilité de calculer la croissance chez l'Anguille par les écailles. Une nouvelle méthode pour marquer les Anguilles: le tatouage. L'âge et le sexe de quelques petites Anguilles de la baie de Pasages (Espagne). Bull. de la Soc. Cent. d'Aquiculture et de Pêche. XXXVI, 42—58, 1929.

MORRISON, N. Hibernation of the Common Eel. Fishing News. 34, 16-II-1929.

RUMPHORST, H. Zwei Fälle von Xanthorismus beim Aal. Mitt. Deutsch. Seefisch. Ver. XXXXV, 123—24, 1929.

FRESH WATER FISH AND POLLUTION

DIENÉRT, F. et ÉTRILLARD, P. Stérilisation des Eaux par le Chlore. C. R. Acad. Sci. Paris, CLXXXVIII, 826—29, 1929.

GILL, R. River Tyne Pollution. Note on some dissolved oxygen Figures during the Smolt Season, 1928. Rep. Dove Mar. Lab. for year ending June 30th, 1928. 47—48, 1929.

GRAY, J. The Growth of Fish. II. The growth-rate of the Embryo of *Salmo fario*. III. The Effect of Temperature on the Development of the Eggs of *Salmo fario*. Brit. Journ. Exper. Biol. VI, 110—30, 1928.

WILLIAMSON, I. J. F. Further Observations on Furunculosis of the Salmonidae 1928. Fisheries, Scotland, Salmon Fish. I, 1929.

Oysters and other Lamellibranchs.

AMEMIYA, I. A Preliminary Note on the Sexuality of a Dioecious Oyster, *Ostrea gigas* Thunberg. Jap. Journ. of Zool. II, 99—102, Tokyo, 1928.

BOURY, M. Étude sur la reproduction des huîtres. Rev. des Trav. de l'Office des Pêches Mar. I, Fasc. 2, 87—98, 1928.

BOURY, M. Remarques sur la mortalité des huîtres. Rev. des Trav. de l'Office des Pêches Mar. I, Fasc. 2, 99—101, 1928.

BOURY, M. Les Gisements huîtriers de la Rade de Brest. La Pêche Maritime, XII, 340, 1929.

COULTHARD, H. S. Growth of the Sea Mussel. Contr. to Canadian Biol. and Fish. N. S. IV, 121—36, 1929.

HINARD, G. et LAMBERT, L. Tableau de l'Ostréiculture française (Première partie). Rev. des Trav. de l'Office des Pêches. Mar. I, Fasc. 3, 36—90, 1928.

PRYTHERCH, H. F. Investigations on the Physical Conditions controlling Spawning of Oysters and the Occurrence, Distribution and Setting of Oyster Larvae in Milford Harbour, Connecticut. Bull. Bur. of Fish. U.S.A. XLIV, 429—503, 1929.

SENO, H. A Contribution to the Knowledge of the Development of *Ostrea denselamellosa* Lischke. Journ. of the Imp. Fish. Inst. XXIV, 129—35, Tokyo, 1929.

SPÄRCK, R. Studies on the Biology of the Oyster (*Ostrea edulis*). V. Rapp. Danish Biol. Stat. XXXIV, 3—14, 1928.

TAKATSUKI, S. The Heart Pulsation of Oysters in Tropical Seas compared with that of those living in seas of the Temperate Zone. Rec. of Ocean. Works in Japan, I, 102—12, Tokyo, 1929.

WASMUND, E. Schalenfischerei an Meeresküsten. Mitt. Deutsch. Seefisch. Ver. XXXXV, 55—71, 1929.

WRIGHT, F. S. Report on a recent Survey of the Llanrhidian (Penclawdd) Cockle Beds. (June 1928). South Wales Sea Fisheries District Committee. Port Talbot. 1929.

Crustacea.

DANNEVIG, A. and MEEK, A. Correspondence. The Rearing of Lobster at Flødevigen. Journ. du Cons. IV, 105—06, 1929.

FISHERY BOARD FOR SCOTLAND. Crab marking experiments, September 1916 to February 1924. Fisheries Scotland. Sci. Invest. 1928, IV, 1929.

Whales and Seals.

AAGAARD, B. Antarctic Whaling and Exploration. Scot. Geogr. Mag. XLV, 65—80, 1929.
GRAY, R. W. The Extermination of Whales. Nature CXXIII, 314, 1929.
GRAY, R. W. Breeding Habits of the Greenland Whale. Nature CXXIII, 564—65, 1929.
GRAY, R. W. Growth and Longevity in Whales. Nature CXXIII, 910—11, 1929.
HJORT, J. and RUUD, J. T. Whaling and Fishing in the North Atlantic. Rapp. et Proc.-Verb., LVI, 5—123, 1929.
INGEBRIGTSEN, A. Whales caught in the North Atlantic and other Seas. Rapp. et Proc.-Verb., LVI, 1—26, 1929.
LEGENDRE, R. Les Bélugas. Bull. de l'Inst. Océan. No. 538, Monaco, 1929.
SCHUBART, O. Die Seehunde der Ostsee und ihr Fang. Zool. Gart. I, Heft 7—9, 1929.

Biological Miscellaneous.

LUNDE, G., CLOSS, K., HAALAND, H. og MADSEN, S. O. Jodinnholdet i norsk fisk og fiskeprodukter (mit deutscher Zusammenfassung). Årsberet. vedkom. Norges Fisk. 1928. No. IV, 1928.
VISSCHER, J. P. Nature and Extent of Fouling of Ships' Bottoms. Bur. of Fisheries. XLIII, 1927, 193—252, 1928.

Notice to Contributors.

1) All contributions should be type-written, on one side of the paper only.

2) Drawings and diagrams for reproduction should be prepared in waterproof Indian Ink (Encre de Chine) on Bristol Board or other perfectly smooth, white paper or card. No erasures should be made. Shading should be limited to the minimum necessary, and when used the shading lines should be kept open. Fine and dotted lines should be drawn boldly.

Lettering should be inserted only in pencil: the block-maker will be responsible for the definitive lettering.

Drawings should if possible be twice the diameter required, and when reduced should occupy a maximum space of 18 cms. in length and 11 cms. in width, including the space for the legend. The shape should be such as to fit easily into the page.

The size to which drawings are to be reduced should be noted in pencil on the originals.

When several illustrations are required for the same article they may be drawn on the same sheet, allowing at least 5 cms. between them.

Charts and curves may be drawn to advantage on graph-paper ruled in pale blue lines, as these lines do not appear in photographic reproduction.

Legends for figures should be type-written on a separate sheet.

3) For satisfactory reproduction of photographs a good glossy bromide print is required, and all added matter, such as reference letters, arrows, numbers etc., should be drawn on the face of the photograph or indicated on tracing paper attached to the back of the print and folded over the front. If matter is written on the face of the photograph a duplicate print without the added matter should be supplied.

Legends should be written on the back of the photographs, or type-written on a separate sheet.

Table of Contents.

Page

1. Obituary notice:— Fr. Heincke 137
2. William F. Thompson. The Regulation of the Halibut Fisheries of the Pacific Coast of North America 145
3. Kurt Buch. Die Verwendung von Stickstoff- und Sauerstoffanalysen in der Meeresforschung 162
4. Martin Knudsen. A Frameless Reversing Waterbottle 192
5. Was. W. Shoulejkin. A Maregraph for the open Sea 194
6. J. Le Gall. Le Thon rouge (*Thunnus Thynnus* L.) en Mer du Nord et dans l'Atlantique Nord Est 200
7. H. J. Buchanan-Wollaston and William C. Hodgson. A new Method of Treating Frequency Curves in Fishery Statistics, with some results 207
8. Correspondence:— (Californian Sardine Investigations) (1) by W. F. Thompson, Seattle; (2) by T. Edser 226
9. Reviews:—
   - Verhandlungen der Ozeanographischen Konferenz anlässlich der Hundertjahrfeier der Gesellschaft für Erdkunde zu Berlin, 24—26 Mai, 1928. Reviewed by J. N. Carruthers 230
   - J. N. Carruthers. The Flow of Water through the Straits of Dover as gauged by continuous current meter observations at the Varne Light-vessel (50°56′ N. 1°17′ E.). Part I. Methods employed, with a Preliminary Survey of the Results. Reviewed by Bruno Schulz 234
   - 1. C. F. Brooks. Reliability of Different Methods of taking Sea Surface Temperatures.
   - 2. G. F. McEwen. Significance of Water Temperature Measurements not made exactly at the Surface.
   - 3. P. M. van Riel. The Influence of Sea Disturbance on Surface Temperature. Reviewed by J. R. Lumby 236
   - Jerry H. Service. Measurement of Salinity of Seawater. Reviewed by D. J. Matthews 238
   - Marie V. Lebour. The Larval Stages of The Plymouth Brachyura. Reviewed by K. Stephensen 238
   - Leif Störmer. Copepods from the "Michael Sars" Expedition, 1924. Reviewed by R. E. Savage 241
   - Winfred Emory Allen. Quantitative Studies on Inshore Marine Diatoms and Dinoflagellates, collected in Southern California in 1924. — Review of Five Years of Studies on Phytoplankton at Southern California Piers, 1920—1924 inclusive. Reviewed by Marie V. Lebour.. 242
   - F. S. Russell. The Vertical Distribution of Marine Macroplankton. VIII. Further Observations on the Diurnal Behaviour of the Pelagic Young of Teleostean Fishes in the Plymouth Area. Reviewed by G. P. Farran 243
   - J. H. Orton. Observations on Patella vulgata. Part I. Sex-Phenomena, Breeding and Shell-Growth. Part II. Rate of Growth of Shell. Reviewed by G. P. Farran 244
   - Erik M. Poulsen. The Haddock in the Belt Sea and the Western Baltic during the Years 1926—1928. Reviewed by Harold Thompson..... 245
   - A. Bowman. Line fishing in the Moray Firth during the period 1904—1916 (inclusive). Reviewed by W. Schnakenbeck 247
   - Guido Schneider. Die Seefischerei von Lettland und Estland. Reviewed by M. Siedlecki 248
   - Paul S. Galtsoff. Experimental study of the Function of the Oyster Gills and its bearing on the Problems of Oyster Culture and Sanitary Control of the Oyster Industry. Reviewed by H. P. Sherwood..... 249
10. Current Bibliography prepared by the Editor with the assistance of Miss Thursby-Pelham 252

BIANCO LUNO — COPENHAGEN